METHODS AND TOOLS

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ESTIMATING MERCURY USE AND DOCUMENTING PRACTICES IN ARTISANAL AND SMALL-SCALE GOLD MINING (ASGM)

Estimating Mercury Use and Documenting Practices in Artisanal and Small-scale Gold Mining (ASGM)

Methods and Tools

Version 1.0

An Artisanal Gold Council (AGC) document
produced in conjunction with
the UN Environment Global Mercury Partnership

This publication should be cited as follows:

O'Neill, J. D. and Telmer, K. (2017). *Estimating Mercury Use and Documenting Practices in Artisanal and Small-scale Gold Mining (ASGM)*. Geneva, Switzerland: UN Environment. ISBN 978-0-9939459-8-4.

Table of Contents

CHAPTER 2 – ASGM BASELINE INSTRUCTIONS


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Who is this guidebook and toolkit for?

This guidebook and toolkit have been designed to assist governments, civil-society organizations, and the private sector of countries in preparing a National Action Plan (NAP) for reducing mercury use in artisanal and small-scale gold mining (ASGM) as required for applicable parties under Article 7 of the Minamata Convention on Mercury.

This guidebook and toolkit are designed as a supplement to the UN Environment guidance document: Developing a National Action Plan to Reduce, and Where Feasible, Eliminate Mercury Use in Artisanal and Small Scale Gold Mining, which offers overarching guidance to countries formulating ASGM NAPs for the Minamata Convention. In addition to providing guidance on determining mercury use, this document also provides some technical, legal, and socioeconomic information on issues related to ASGM, which may be useful when preparing and implementing the NAP.
These documents are for guidance only and are not mandatory or required for use under the Convention.

How does this guidebook and toolkit contribute to the National Action Plan?

Under Article 7 of the Minamata Convention on Mercury, each Party (country) shall notify the Secretariat if at any time the Party determines that artisanal and small-scale gold mining and processing (in which mercury is used) in its territory is more than insignificant. If it so determines, the Party shall (a) develop and implement a National Action Plan (NAP) in accordance with Annex C; (b) Submit its NAP to the Secretariat no later than three years after entry into force of the Convention or three years after the notification to the Secretariat, whichever is later; and (c) Thereafter, provide a review every three years of the progress made in meeting its obligations under this Article.

Minamata Convention on Mercury - Annex C

Artisanal and small-scale gold mining

1. Each Party that is subject to the provisions of paragraph 3 of Article 7 shall include in its national action plan:

   (a) National objectives and reduction targets;

   (b) Actions to eliminate:

   - Whole ore amalgamation.
   - Open burning of amalgam or processed amalgam.
   - Burning of amalgam in residential areas.
   - Cyanide leaching in sediment, ore, or tailings to which mercury has been added without first removing the mercury.

   (c) Steps to facilitate the formalization or regulation of the ASGM sector.

   (d) Baseline estimates of the quantities of mercury used and the practices employed in artisanal and small-scale gold mining and processing.

   (e) Strategies for promoting the reduction of emissions and releases of, and exposure to, mercury in ASG mining and processing, including mercury-free methods.

   (f) Strategies for managing trade and preventing the diversion of mercury and mercury compounds from both foreign and domestic sources to use in ASG mining and processing.

   (g) Strategies for involving stakeholders in the implementation and continuing development of the NAP.

   (h) A public health strategy on the exposure of ASG miners and their communities to mercury, including gathering of health data, training for health-care workers and awareness-raising through health facilities.

   (i) Strategies to prevent exposure of vulnerable populations, particularly children and women of child-bearing age, especially pregnant women, to mercury used in ASGM.

   (j) Strategie s for providing information to artisanal and small-scale gold miners and affected communities.

   (k) A schedule for the implementation of the national action plan.

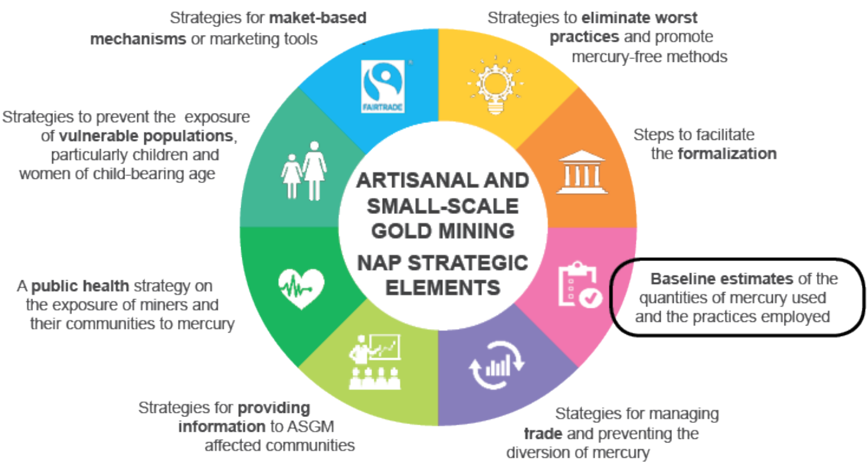
2. Each Party may include in its national action plan additional strategies to achieve its objectives, including the use or introduction of standards for mercury-free artisanal and small-scale gold mining and market-based mechanisms or marketing tools.

This guidebook and tooklit enable a research team to:

1 Plan for, collect, and analyse data to satisfy requirement (d) of the Minamata Convention – *Baseline estimates of the quantities of mercury used and the practices employed in ASGM*. The methods introduced here can be used to find an initial (baseline) estimate of ASGM mercury use and practices for the NAP. It can also be used in follow-up mercury monitoring, when estimates of mercury use are made at regular intervals defined in the NAP.

2 Establish an ASGM knowledge base within the country. This knowledge base can be drawn on to create national objectives, reduction targets, and exposure prevention strategies that are relevant and realistic (a, b, i), strategies for formalisation and managing mercury trade that are informed by on-the-ground insight and statistics (c, f), strategies for the promotion of mercury-free methods and stakeholder buy-in (e, g), information distribution to ASGM communities and health facilities that are appropriate and targeted to areas in need (h, j), and a realistic timeline for NAP implementation that considers a full view of the country's ASGM sector (k).

Obligations (a) – (c) and (e) – (k), however require further rigorous investigation that are outside the scope of this guidebook. Additional guidance materials on these topics are available on the UN Environment National Action Plan Website[1].



[1] *http://web.unep.org/chemicalsandwaste/global-mercury-partnership/asgm/national-action-plans*

How is this guidebook and toolkit organized?

This is an instruction manual as well as an educational and training resource. It is organized in three parts: Chapter 1: Sector and Baseline Comprehension; Chapter 2: Baseline Instructions; and the third part, Annexes (Annex A: Baseline Support Tools and Annex B: Training Module).

Chapter 1 provides background on the ASGM sector and ASGM baseline methodology. A strong understanding of the sector is vital to carrying out successful and efficient baseline research, and thus a clear comprehension of the material in Chapter 1 will save time and resources. The introduction to baseline research includes a description of the general process, where to find information, how to collect and analyse data from existing sources and in the field, and how to extend site data to a country scale.

Chapter 2 is an adaptable set of instructions outlining how to carry out the ASGM baseline research. It describes when, where, and how to use each of the resources in the toolkit to plan for, collect, analyse, and report baseline data. It elaborates the tasks required at each research step, from staff hire, through data collection and analysis, to final reporting. Each step references helpful tools from Annex A.

Annex A, the baseline support tools, is a collection of materials designed to streamline the baseline process. The tools of Annex A include the following:

- A1: Printable interview and data collection forms
- A2: Data entry workbooks and reporting templates for sector scoping (documenting exisiting data on the sector)
- A3. Data entry and analysis workbooks
- A4: List of common equations and formulas

Annex B, the training module, is a package of presentation slides, course syllabus, and a practice exercise designed to help train the baseline team.

What will be accomplished with this guidebook and toolkit?

The ASGM baseline guidebook and toolkit enable the reader to:

1. Create a comprehensive national overview of ASGM practices;
2. Design a baseline research plan that aligns with allotted resources;
3. Collect relevant data from a variety of sources;
4. Develop robust baseline estimates of annual ASGM mercury use, gold production, and workforce within the country.

How to use this guidebook and toolkit

First, read Chapter 1 to understand what will be encountered during the research and to become familiar with terms and concepts used in the instructions of Chapter 2. Even for those who are already familiar with the ASGM sector, Chapter 1 should not be overlooked. ASGM is very complex, largely understudied, and often misunderstood. Chapter 1 prepares the researcher to plan and conduct the kind of research that will yield both a comprehensive overview of ASGM practices and a robust baseline estimate that can stand up to critique. Preparation topics include:

- how to plan for and carry out information scoping, interviews, and physical measurements;
- where good sources of information are found;
- where and how research efforts should be focussed;
- how the sector may differ between regions and how this affects research;
- how to assess data quality;
- how to ensure estimates are reliable by comparing multiple sources.

Once prepared, move on to the instruction guide in Chapter 2 to carry out the ASGM baseline research, utilising as needed the suite of tools found in the Annex A. A checklist / schedule is provided at the beginning of Chapter 2 to track progress of the research. If unsure about a term, concept, or equation, consult the glossary and list of acronyms at the end of this guidebook, the list of common equations in Annex A4, and the practice exercise found in Annex B.

The ASGM expert tasked with training the baseline team will find helpful training materials (lecture slides, course syllabus, and a practice exercise handout) in Annex B.

Challenges

While the concept may seem simple, it can be challenging to obtain reliable estimates from the ASGM sector. Artisanal mining is often informal with little government oversight and few reliable statistics on production and sales. Most often, finding reasonable estimates of ASGM mercury use, gold production, and workforce requires extensive site visits, multiple interviews with miners, gold buyers, local government officials, and others, plus additional observations and physical measurements on ASGM sites. The feedback from these different sources can vary greatly, and must be interpreted. Often through the act of performing research, new insights are discovered that assist in the interpretation. A reliable estimate is the result of compiling and comparing similar information from numerous sources. Only in this way can reasonable confidence be reached.

Skills, people, and resources required for ASGM baseline research

ASGM baseline research requires a team of people with specific skills. The team lead must have a thorough understanding of ASGM, geology, the scientific method, and Minamata NAP requirements. She or he must have strong skills in the acquisition, management, analysis, and reporting of data and must be a strong communicator and writer to impart training and deliver results.

The field component of the research requires a team who are quick thinking, open-minded, and good problem solvers. Ideally, team members should have experience in the field, skills in the acquisition and management of data, and basic comprehension of the scientific method. They must understand the ASGM sector (initially or through training) and must be given plenty of practice in baseline problem solving in the classroom and field. Finally, and perhaps most importantly, researchers must be friendly and communicative and able to adapt their approaches quickly when new scenarios are encountered. Ultimately, the Baselining Team is responsible for the quality of the ASGM Estimates. Team members need to comprehend and collect thoughtful, relevant and high-quality data that involves significant financial, time, and opportunity costs. For this reason, one of the biggest determinants of success is the selection of a capable team.

Other reference documents

Minamata Convention on Mercury. Available at *www.mercuryconvention.org* and *www.treaties.un.org.*

UN Environment Guidance Document: Developing a National Action Plan to Reduce, and Where Feasible, Eliminate Mercury Use in Artisanal and Small Scale Gold Mining. Available at *http://web.unep.org/chemicalsandwaste/global-mercury-partnership/asgm/national-action-plans.*

Toolkit for Identification and Quantification of Mercury Releases, Reference Report and Guideline for Inventory Level 2, Version 1.2 April 2013, UNEP – United Nations Environment Program.

A Practical Guide: Reducing Mercury Use in Artisanal and Small-scale Gold Mining. UNEP Global Mercury Partnership document produced in collaboration with the Artisanal Gold Council (AGC) and with assistance from the United Nations Industrial Development Organization (UNIDO), University of Victoria, and the International Union of Geosciences Commission on geosciences for Environmental Management (IUGS-GEM); 2012. Available at *wedocs.unep.org* and *www.artisanalgold.org*

Using Retorts to Reduce Mercury Use, Emissions, and Exposures in Artisanal and Small-Scale Gold Mining: A Practical Guide, An Artisanal Gold Council (AGC) document, produced in collaboration with the U.S. Department of State (USDOS), UNIDO, and IDRC; 2014. Available at *wedocs.unep.org* and *www.artisanalgold.org*

CHAPTER 1

ASGM SECTOR AND BASELINE COMPREHENSION

"To successfully complete estimates of ASGM mercury use, a crucial first step is to build a baseline team that understands the technical, social, economic, political, and ore processing context" [1]

~

The following chapter introduces key aspects of ASGM. During baseline research, each of these aspects will be an important source of information.

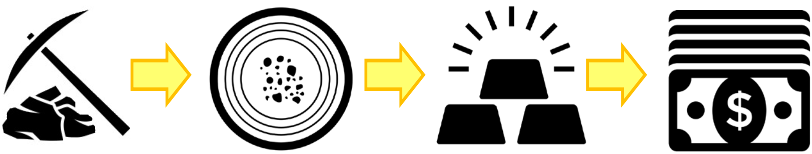
[1] UN Environment Guidance Document: Developing a National Action Plan to Reduce, and Where Feasible, Eliminate Mercury Use in Artisanal and Small Scale Gold Mining.

1. Introduction to ASGM

1.1. What is ASGM?

Artisanal and small-scale gold mining (ASGM) is gold mining conducted by individual miners or small enterprises with limited capital investment and production. It is typically a de-centralised production system. Various governments may have established varying definitions of ASGM to suit their jurisdictions. Some define it by the magnitude of ore processed (*e.g.,* less than 300 tonnes per day) and some by the mining and processing methods used (*e.g.,* manual and/or semi-mechanised techniques). It is important to know how it is defined.

Generally speaking, gold-bearing ore is extracted from the earth and processed via one of many manual or semi-mechanised techniques to produce gold, which is then converted to currency through sale[2].



ASGM differs from large-scale mining (LSM). LSM produces gold on a larger scale using fully mechanized extraction and processing methods. An important difference between the two sectors is that ASGM transfers wealth more directly to larger populations of local workers in rural parts of developing countries. Both conflict and cooperation exists between LSM and ASGM in many countries, although conflict is more common. An integrated gold production system that involves stronger collaboration between LSM and ASGM may emerge in the future.

[2] Icons by Clément Branger, art shop, Putu Kharismayadi, and Creative Stall, respectively, from the Noun Project.

1.2. Where Does ASGM Occur?

ASGM has been documented to occur predominantly in the rural parts of 81 developing countries (GMA, 2013[1] & 2018[2]). It is a major gold producer and also the world's largest employer in gold mining, representing about 20% (400 – 600 T/year) of global gold production (3200 T/year[3]) and 90% of the global gold mining workforce.

ASGM may be formal or informal depending on the laws of each country and the ability of miners to comply with these laws. However, ASGM is recognized by many countries and the world's international development agencies, such as the United Nations and World Bank, as a significant poverty relief mechanism and an important opportunity for development. Artisanal gold is an excellent mechanism for transferring wealth from the urban wealthy to the rural poor where there are few other economic opportunities. Incomes in ASGM can be two- to ten-times those typically found in rural agrarian economies.

[1] UNEP, 2013. Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland

[2] UNEP, 2018 (to be published). Global Mercury Assessment 2018: Sources, Emissions, Releases and Environmental Transport. UNEP Chemicals Branch, Geneva, Switzerland.

[3] https://www.gold.org/research/gold-demand-trends/gold-demand-trends-full-year-2016/supply

1.3. Mineralogy

1.3.1. Gold Deposits

Natural processes cause gold to be concentrated in certain geological formations. The concentration can happen through deep earth processes like volcanic activity, where gold is introduced by hot fluids into veins, or through surface processes like chemical and physical weathering, where gold is liberated by erosion and concentrated by the transport of sediments.

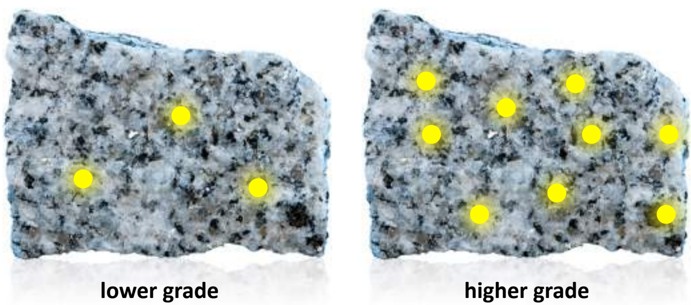
A sample of gold-bearing rock mined from a gold-bearing vein (hard rock deposit).

Gold in surface sediments (soft rock or alluvial/colluvial deposits).

The rock or sediments containing gold that are targeted by miners is called **gold ore**. To produce gold, the ore must be processed to remove the other minerals, leaving behind a gold concentrate.

1.3.2. Ore Grade

The amount of gold contained within the ore is called its **grade**. Ore grade is expressed as the weight of the gold (*e.g.*, grams) present in the total weight of the ore (*e.g.*, tonnes). A typical grade unit is g/T. Artisanal miners target small deposits of high-grade ores. A typical hard rock grade targeted by artisanal miners is around 20 g/T. This means that to produce 20 g of gold, 1 tonne of ore would need to be extracted and processed. A typical soft rock (alluvial) grade targeted by artisanal miners is about 0.1–1 g/T and an alluvial operation moves about 100 T of sediment per day, generating about 10–100 g of gold per day. But numbers vary.



There are two important concepts of ore grade that you might encounter. **Total grade** is simply the amount of gold in the ore and is determined by sophisticated laboratory measurements (assaying). But it is nearly impossible to get 100% of the gold out of the ore. The **recoverable grade** is the amount of gold that is extracted by the miners using their processing method. The rest of the gold remains in the tailings (waste rock). Recoverable grade can range from as low as 20% to as high as 95% of the total grade. Because ASGM processing techniques are often basic, the recoverable grade is often significantly lower than the total grade.

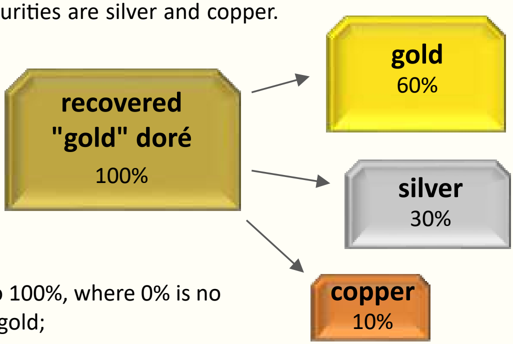
Relevance

When an ASGM worker or stakeholder quotes an ore grade, they are typically quoting the recoverable grade. If the amount of ore and the recoverable grade of the ore are known, then the amount of gold produced can be calculated.

(T ore) x (g/T recoverable grade) = g of gold produced

1.3.3. Gold Purity

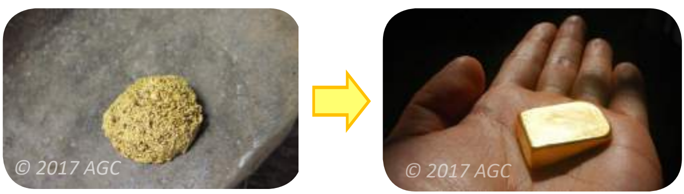
Naturally occurring gold is not pure. It is a mixture of gold and impurities. Typical impurities are silver and copper. A bar of this composite of naturally occurring purity is called gold **doré**.



The **purity** of gold is commonly expressed in karats or percent.

- **A percent scale of purity** ranges from 0 to 100%, where 0% is no gold and 100% is pure gold;
- **A karat scale of purity** ranges from 0 to 24 karats, where 0 karats is no gold, 24 karats (24 K) is pure (99.9%) gold. 22 K is 91.7% (22/24).

Purity can vary significantly between ASGM mining sites, but less variation is expected within a site.



Impure gold (*e.g.*, 18K or 75%) can be purified (24K or 100%) by refining it. To convert a mass of doré into its equivalent mass if it was refined to 100% purity, use the following equation:

(mass pure gold) = (mass doré) × (purity of doré (%))

Relevance

Gold mined on one site will often have a different purity than on another site, based on geology. To compare amounts of gold produced between sites, you must standardize to 100% pure (24K) gold. Another reason to standardize to 100% pure gold is to calculate the value of the gold when sold, as the buying price is often stated in currency per gram of pure gold.

1.4. Extraction: Mining Ore

1.4.1. Types of Mineral Deposits

Hard rock

Hard rock is a solid deposit of minerals that has not been broken down or transported. Examples of hard rock are granite or a gold-bearing quartz vein. Hard rock is also known as a primary ore deposit.

Soft rock

Soft rock, or an alluvial deposit, is a loose deposit of sediments. These sediments are derived from the physical erosion of hard rocks and are moved by wind and water to produce alluvial sediment. Alluvial sediments include gravel and sand beds in rivers and deposits of old river sediments.

Relevance

The type of mineral deposit is important because it dictates which methods are used to extract the gold from the ore. Similarly, it also dictates the strategy for reducing mercury use.

1.4.2. Extraction Units

An extraction unit is the location from which ore is extracted. During **hard rock mining**, ore may be extracted from the walls of mine shafts, which are narrow underground tunnels following the direction of a gold-bearing vein, or from small to large open pits, which do not extend underground. Mine shafts in ASGM can extend in vast disorganized networks that are kilometres in length and reach up to 100 m below the surface. Organizing the underground workings of ASGM remains one of its greatest challenges.

During **soft rock (alluvial) mining**, alluvial ore is extracted from deposits of sediment that occur naturally along present-day or former riverbeds and deltas. There are also soft rock ASGM operations that source ore from tailings piles.

Relevance

An extraction unit is the most basic unit of ore extraction on an ASGM site. If the number of extraction units on site is known, along with the average size of the extraction group per extraction unit, the mining workforce for the site can be determined.

workforce = (# extraction units) x (# workers per extraction unit)

1.4.3. Extraction Equipment

At hard rock mines, ore may be removed **with picks, shovels, excavators, loaders, jack hammers,** and/or **blasting with dynamite**. **Rope** and **pails** may be used to bring the ore to the surface, and ore is then often transported in **sacks**.

At soft rock sites, alluvial sediment may be removed with **shovels**, **buckets**, **excavators**, **loaders**, and **spraying with water** (hydraulic mining).

Relevance

Knowing which tools are used for extraction will give an initial indication of the scale of production on a site and may provide ideas for technical improvements. Production will be greater at sites using mechanised or semi-mechanised tools and lesser at sites using strictly manual methods for extraction.

1.4.4. Organization of Extraction Workers

Miners can be organized in many ways. For example, mining can be done by individuals, small groups, or large groups directed by a crew boss or site owner.

individual miners

small groups

large groups + site owner

1.5. Transport: Linking Extraction and Processing

Once ore has been removed from the ground it must be transported to the processing location. It may be moved in loose form by truck or excavator or in sacks/bags/pails/ on wheelbarrows, bicycles, push-karts, animals (horses, mules, *etc*.), or motorized vehicles (tuk-tuks, pick-up trucks, excavators, dump trucks, *etc*.).

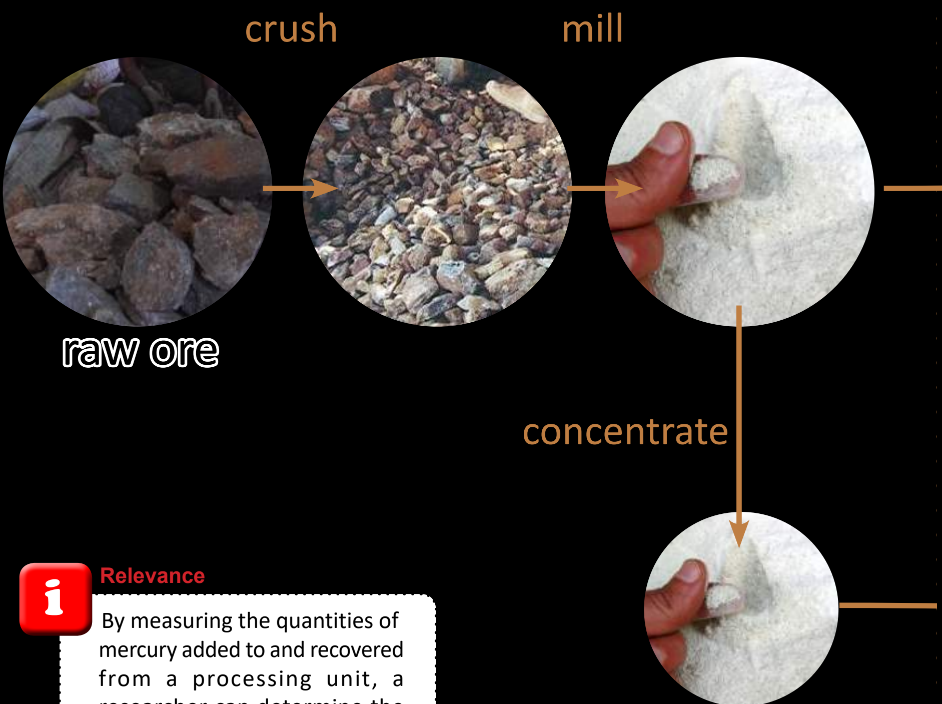
Relevance

Understanding transportation can provide a useful gauge of production, which ultimately is tied to the quantity of mercury used. Production can be estimated by counting the sacks or transport units (*e.g.*, trucks) departing an extraction site. If the average weight of a sack is known,

daily ore production = (weight of sack) x (number of sacks per day)

1.6. Processing: Liberating Gold from Ore

Processing equipment may be located on the extraction site or at a specific processing location. It may be owned by an individual miner, a mining cooperative, the site/land owner, or operated as a service-for-fee business (*e.g.*, toll milling). There are other possibilities too.

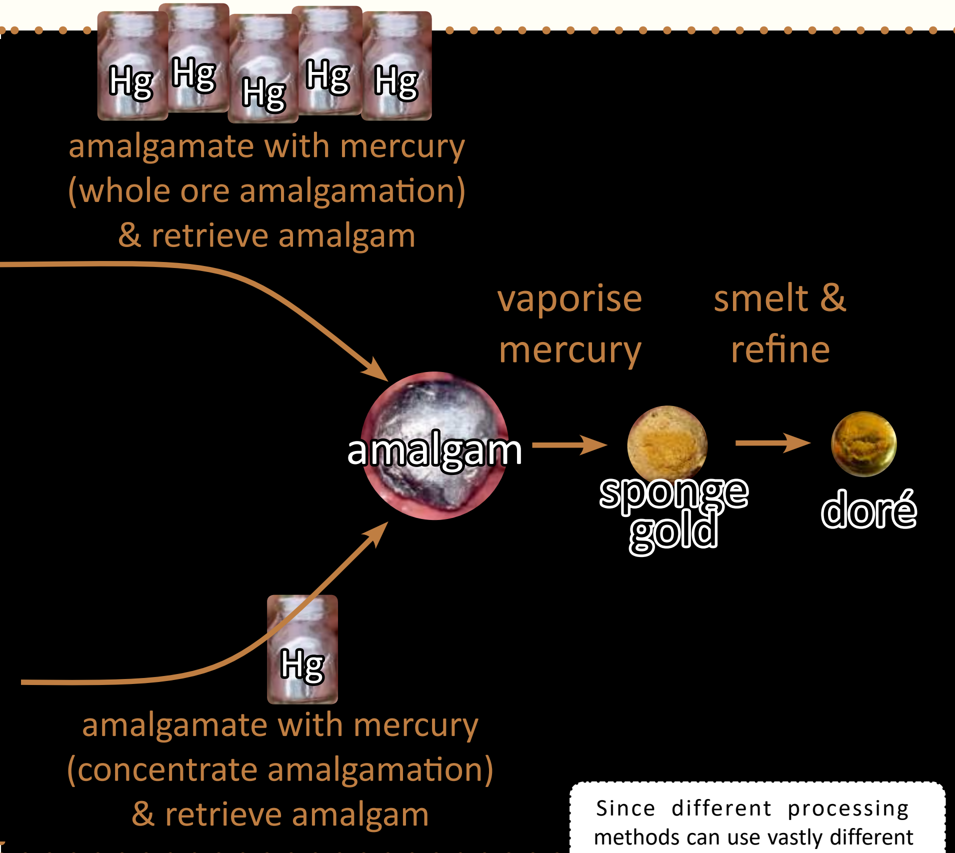


Relevance

By measuring the quantities of mercury added to and recovered from a processing unit, a researcher can determine the amount of mercury that is used (lost to the environment) per gram of gold produced at that unit. This information can be used to estimate mercury use from a statistic of ASGM gold production.

1.6.1. Processing Method

The variation found in processing technology and methods is large. However, the general sequence involving mercury use is usually similar and is depicted in the panel below. More detail on each step is found in the panels on the following pages.



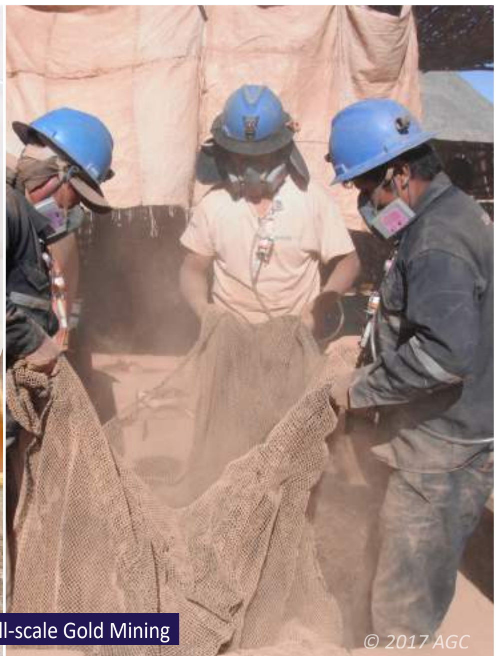
Since different processing methods can use vastly different amounts of mercury, it is important to document which methods are used in the country, where they are located, and how much mercury is used by each.

1

Crushing: Ore is reduced from large rocks down to smaller gravel by crushing. Ore can be crushed manually with a hammer or mechanically with various types of machines.

3

Grain size control: The milled ore may be passed through screens or sieves to strongly control grain size output. Gold recovery is improved when grain size control is practiced deliberately. Proper grain size control liberates more gold from the other minerals, allowing it to be recovered. Poor grain size control results in less effective gold liberation and poorer gold recovery as some of the gold will remain trapped inside other minerals or agglomerations.



2

Milling: The crushed ore is milled to a smaller and more uniform grain size.

4

Concentration: Gold is very heavy and hydrophobic. These unique properties can be exploited to separate gold from the other minerals in the milled ore. Tools used to concentrate gold include pans, sluices, jigs, shaker tables, centrifuges, flotation, and others. Many of these tools use gravity to separate heavy gold from other, less heavy, minerals. Some, such as flotation, exploit the surface properties of the minerals to separate them. In some cases, concentration can be very effective and a rich concentrate of gold can be directly smelted to produce doré, with no other steps (*i.e.*, skip to Step 8). In other cases, ore is partially concentrated, and additional concentration steps are required if mercury is to be avoided.

5 Mercury amalgamation:

Mercury is mixed with the ore to separate the gold from the other minerals. Mercury binds to gold and some other metals to form a solid **amalgam** that is roughly half mercury and half gold.[1] Mercury forms a poorer amalgam with silver and so ores rich in silver often consume a lot of mercury.

If the mercury is added to an ore concentrate, the process is called

concentrate amalgamation

6 Recovering the amalgam (squeeze):

The amalgam and residual liquid mercury is now easily retrieved by gravity, often using panning. It is squeezed through cloth or leather to separate the solid amalgam from the excess liquid mercury. The excess liquid mercury is saved for re-use or thrown away if miners think it is too dirty to effectively capture more gold.

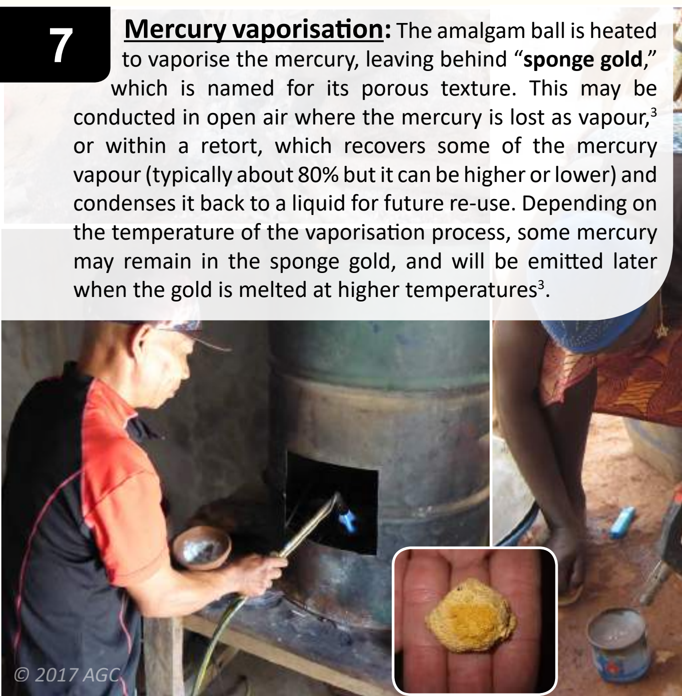
If the ore is not concentrated and mercury is added to all of the milled material, the process is called

whole-ore amalgamation (WOA)

and consumes significantly more mercury than concentrate amalgamation.[2]

7 **Mercury vaporisation:**

Mercury vaporisation: The amalgam ball is heated to vaporise the mercury, leaving behind "**sponge gold**," which is named for its porous texture. This may be conducted in open air where the mercury is lost as vapour,[3] or within a retort, which recovers some of the mercury vapour (typically about 80% but it can be higher or lower) and condenses it back to a liquid for future re-use. Depending on the temperature of the vaporisation process, some mercury may remain in the sponge gold, and will be emitted later when the gold is melted at higher temperatures[3].



[1] A mercury-silver amalgam is roughly 3:1 mercury to silver by mass, so if there is silver present then mercury consumption will be higher. *e.g.*, for a mixture of 1 gram of silver and 1 gram of gold, 4 grams of mercury would be used to form an amalgam.

[2] Whole-ore amalgamation (WOA) consumes significantly more mercury because large amounts of mercury are lost to the waste stream (tailings). For this reason, it is defined as a "**worst practice**" by the Minamata Convention (see panel). If WOA is encountered, the NAP must propose actions to eliminate the practice.

[3] When mercury amalgam is vaporised in open air without a retort or when a retort is used improperly, it exposes workers and residents to toxic mercury vapour. When amalgam is vaporised in a building or enclosed structure, some of the mercury adheres to the ceiling and walls and then desorbs back into the air over time causing continuous long-term exposure. For these reasons, open vaporisation is defined as a "worst practice" by the Minamata Convention. If amalgam or processed amalgam is seen being vaporised in open air or in residential areas, the NAP must propose actions to eliminate the practice.

8 **Smelting:** Sponge gold is separated from impurities by melting it into a solid gold doré ingot and a small amount of slag. The doré will vary in purity depending on the nature of the gold deposit. The doré can be further purified (usually by a gold shop or refinery) to achieve pure 24K gold.

Chemical Leaching (Cyanidation)

ASG miners may recover gold from ore or tailings by leaching with chemicals. The most common method of chemical leaching is cyanidation. In this process, cyanide is added to milled ore and water. The gold in the ore is dissolved to form a water-soluble gold-cyanide complex. A common method used by ASG miners to recover this gold is to absorb the gold-cyanide complex into hard carbon and then burn the carbon to yield the gold. Another common method is to precipitate the gold onto zinc and then dissolve the zinc with acid leaving behind a gold paste which is then melted and poured into a bar. Industrial miners do not burn the carbon but rather desorb ("elute") the gold and re-use the carbon.

Chemical leaching is a very common practice in industrial mining because it is cheap, recovers much more gold (often greater than 90%), and, unlike mercury, it is not a global pollutant nor is it persistent – it is a degradable chemical compound which can be destroyed. When used properly it can be safe for human and environmental health.

9

Reprocessing tailings: If enough gold remains in the tailings (processing waste) for a profitable recovery, tailings may by reworked to recover more gold. This is often done by ASG miners themselves and can involve further use of mercury. Tailings can also be reworked by concentrating further gravimetrically or by chemical leaching using industrial operations. In this case it is important that any mercury contained in the tailings is not remobilised into the environment. Specifically, the Minamata Convention lists the application of cyanide on mercury contaminated tailings as a "worst practice" for reasons explained below.

However, cyanide forms a complex with mercury in the same way that it does with gold, so when cyanidation is practiced on mercury contaminated tailings, it mobilises mercury and spreads it more rapidly in the environment. The cyanide-mercury complex can move through surface and groundwaters and when the complex breaks down, the residual elemental mercury can evade to the air. The cyanide-mercury complex is more bioavailable than elemental mercury and has an increased chance of methylation into its more toxic form *(see p. 31)*. Lastly, mercury consumes cyanide and makes the leaching of gold less efficient. For these reasons, it is defined as a "**worst practice**" by the Minamata Convention. If *cyanide leaching in sediment, ore, or tailings to which mercury has been added without first removing the mercury* is encountered, the NAP must propose actions to eliminate the practice.

1.6.2. Processing Method Determined by Mineralogy

For hard rock mines, typical processing steps involve crushing, milling, and concentrating (often panning or sluicing). Mercury may be added at the milling stage (whole ore amalgamation), or at the concentrated stage (concentrate amalgamation) to capture gold in an amalgam.

For alluvial mines, crushing and milling are usually not necessary, as erosion and transport have already liberated the gold. Typical steps include several stages of concentration such as sluicing and then panning to produce a high-grade concentrate. Mercury may be added at the sluicing stage (whole-ore amalgamation) or during panning (concentrate amalgamation) or not at all if the gold is coarse and abundant. In some cases, there is misguided or superstitious use of mercury which does not in reality recover any additional gold. An example of this is sprinkling mercury on the deposit before processing occurs (Suriname).

1.6.3. Processing Units

A processing unit is the most basic unit of ore processing on an ASGM site. A processing unit could be defined as a set of individual processing components operating together, which accomplish some or all of Steps 1 through 9 of the processing method (*e.g.*, crusher plus a set of six mills and one sluice), or it could be defined at a finer scale (*e.g.*, one mill or one sluice or one panner).

Relevance

A processing unit is the most basic unit of ore processors on an ASGM site. Data related to ore processing (*e.g.*, throughput, gold production, mercury use) are measured per processing unit and can then can be scaled up to site- or regional-level estimates if the total number of units in the site or region is known. For clarity and consistency, what exactly comprises a processing unit should be defined at the outset of baseline research.

1.6.4. Mercury Use During Processing

The term "**mercury use**" means **the net loss of mercury during ore processing**. In other words, it is the **amount of mercury that is lost to the environment** during ore processing operations.

Mercury amalgamation (Step 5): Mercury is added to the ore with water, mixed, and then recovered. However, recovery is much less than 100%. Some mercury is lost to the waste stream (tailings), and thus to the land and water.

Amalgam squeeze (Step 6): some mercury is lost to land and surface water when squeezed mercury spills on the ground or back into the tailings water. Additional mercury is lost when miners discard "dirty" mercury that they no longer feel can recover gold. When determining amounts of mercury lost, the amount thrown away must be considered.

Vaporisation (Step 7): When the amalgam is heated to vaporise mercury and produce sponge gold, mercury is lost in vapour form to the atmosphere. If no retort is used, 100% of the mercury in the amalgam is lost to the atmosphere. If a retort is used, a portion of the mercury in the amalgam is lost as vapour – typically around 10 - 20%.

How is mercury lost to the environment?

Smelting & further refinement (Step 8): A small amount of mercury may remain in the sponge gold (2-5%), with larger pieces containing more mercury. This mercury will be lost to the atmosphere later when the sponge is melted, smelted, and/or further refined.

Cyanidation (Step 9): When cyanidation is practiced on mercury contaminated tailings, it increases the mobility of mercury in the environment. Mercury is lost to land and water and air at the site of cyanide application and the site of tailings disposal. Significant amounts of mercury can be emitted to the air when the activated carbon used to recover gold is burned. Further still, some miners apply mercury to the ash produced from burning the carbon to recover the gold.

Improper storage: Mercury can be lost because of the improper handling (*e.g.*, spills) and storage of mercury. Mercury should be stored with a layer of water on its surface and in an air-tight container, else loss by evaporation occurs.

1.7. Workforce

ASGM provides a primary income for around 10 – 15 million miners in at least 81 developing countries (GMA, 2013), including approximately 3 million women and children. The sector supports roughly 100 million people worldwide.

The **primary ASGM workforce** is the number of workers directly employed in the gold production system or, in other words, all those that receive direct payment from the gold proceeds. The primary workforce includes miners (extraction workers, processing workers, mining/processing foremen), business owners, mining coordinators, cooperative leaders, and other related roles.

The **secondary ASGM workforce** is the number of people who are financially dependent on the ASGM sector or, in other words, all those who provide goods and services to the ASGM sector. The secondary workforce includes agricultural producers, merchants, traders, and service providers. Often a multiplier of 5 or 6 is used to estimate the size of the secondary workforce.

The total number of people supported by the ASGM economy is in fact even larger and is composed of the primary workforce, secondary workforce, and dependents such as families.

Relevance

Primary and secondary workforce are important variables to include in the ASGM sector overview, as they indicate the scale of ASGM activity and the extent to which the population depends on the sector. Knowledge of the workforce can also be a useful gauge of gold production if the average productivity of a typical worker is reasonably estimated.

daily ore extraction = (miner workforce) x (daily ore extraction per miner)
daily gold production = (miner workforce) x (daily gold production per miner)

The gold production can then be used to help determine mercury use.

1.7.1. Workforce Roles

Note that “miner” is a term used for all workers directly involved in gold production. In some situations, all miners are involved in all aspects of gold production – both extraction and processing. This is common in alluvial mining. In other situations, miners are segregated into those involved in extraction of ore ("extraction workers") and those involved in processing of ore ("processing workers"). This is often the case in hard rock mining.

Relevance

Awareness of these roles and how people are described is important, especially when determining workforce numbers. For instance, counting processing workers and extraction workers and then adding them to obtain primary workforce may be legitimate on a site where the roles are separate, but may overestimate the workforce on a site where all miners perform all roles.

1.7.2. Gender

Approximately three million women and children are involved in the global primary ASGM workforce. Women may work as miners, mine owners, cooperative members, or community leaders, among other mining-related roles. The role of women in the ASGM mining workforce varies between and within countries. Despite the critical role that women play in mining and in many mining communities, and the importance of artisanal mining as a livelihood and opportunity for rural women, relatively little gender aggregated data has been collected on the ASGM sector. There remains a paucity of information on women in ASGM mining.

Relevance

Gender disaggregation of data is essential when documenting community population, community leaders, and extraction and processing workforce. This information is needed to design intervention strategies that clearly account for the health and needs of women. In this light, it is also important to record the roles of women robustly in the indicated space.

1.8. Governance and Formality

Formal policy and governance structures for ASGM are young and remain under development in most countries so to a large degree, ASGM operates in the informal economy. However ASGM does typically operate under a relatively sophisticated governance system that contains most of the relationships seen in a formal governance system (*e.g.*, community leaders, land owners, security providers, profit sharing arrangements). The system has been created by the mining community itself and often contains varying degrees of cultural influence, innovation, common sense, and fairness or unfairness, as well as influences reflecting local, regional, and national authorities.

It is important to understand the operating governance system in order to estimate mercury use, to understand why people use mercury, and to evaluate the potential effectiveness of mercury reduction interventions.

Individual mining operations can be organized in many ways. Three common examples (Figure 1-1) of site organisation are:

(1) Individual miners extract and processes ore and sell gold.
(2) Miners work in a group like a small business, with the business owner providing supplies and distributing the earnings.
(3) Miners work together in a co-operative.

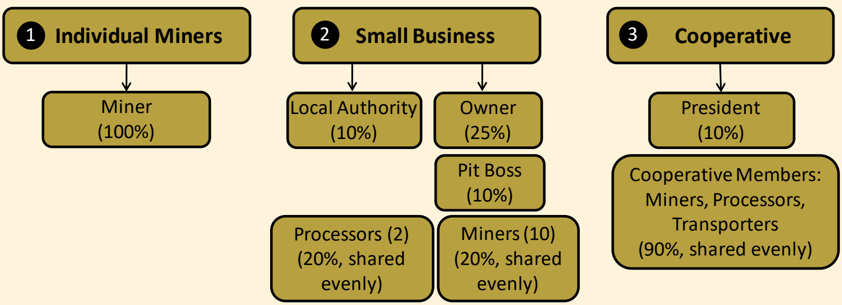
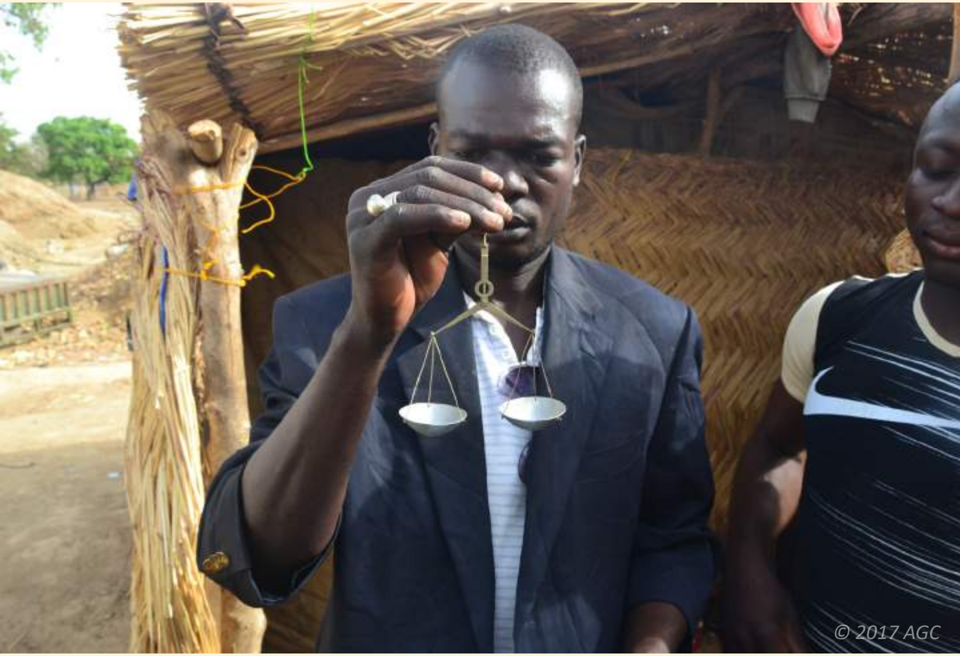


Figure 1-1. An example of three common ASGM governance structures and their earnings distribution (percentages). Note that in some cases, a local authority may collect a formal or informal tax, as illustrated in (2).



Relevance

When planning baseline research, it is important to understand the scale (national, regional, local) and the structure of governance. This understanding is essential in estimating annual gold production based on earnings (see *7.4.1. Earnings-based Estimates, p. 72*). In this approach, the governance system is used to estimate revenue distribution, which in turn is used to estimate gold production and ultimately mercury use. Knowing the governance structure will also enable a researcher to identify and interview important stakeholders with specific knowledge (*e.g.*, mining coordinator, head of cooperative, local leader).

1.9. Commercialisation

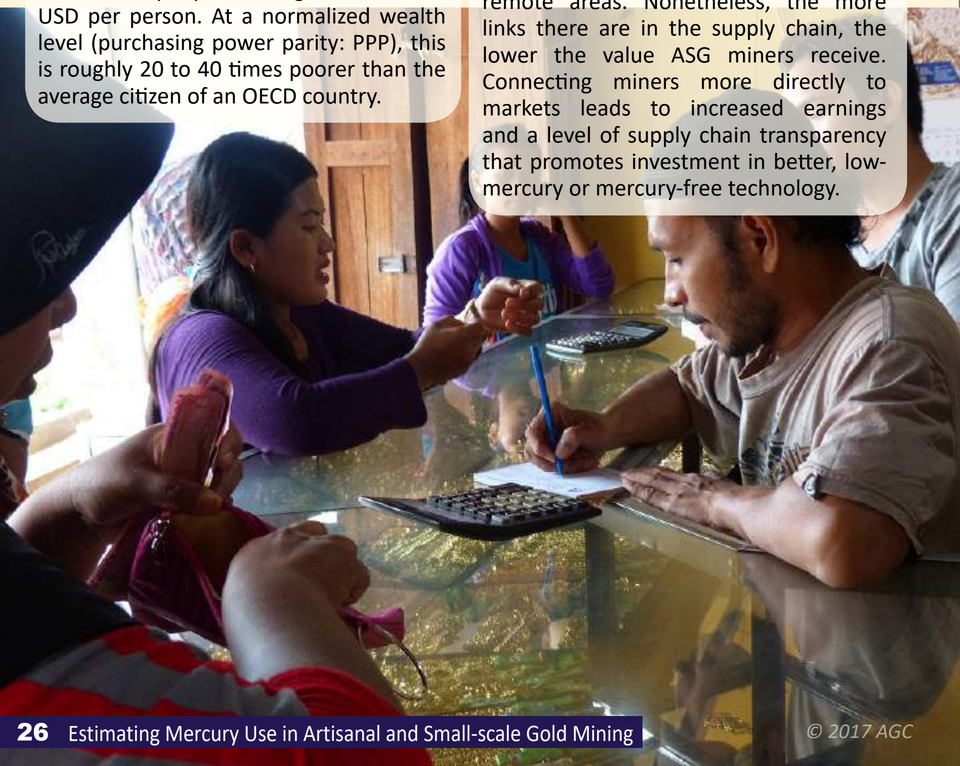
1.9.1. Economy

At 1250 USD/oz (40.19 USD/g) and 10 million people producing around 500 T of gold per year, ASGM gold production has an annual gross value of around 20 billion dollars. This equates to about 2000 USD/miner per year or 0.25 g production per miner per working day for 200 days/ year. The variance on this average figure is broad and this statistic is only used as a global aggregate average.

The secondary economy of ASGM, using a conservative multiplier of 5 is around 100 billion USD annually and involves 50 to 100 million people earning 1000 to 2000 USD per person. At a normalized wealth level (purchasing power parity: PPP), this is roughly 20 to 40 times poorer than the average citizen of an OECD country.

1.9.2. Gold Supply Chains

Typically, an ASG miner sells to a local gold buyer. The gold then moves through one or several regional buyers and traders and an exporter before reaching the formal or informal refineries and international markets (Figure 1-2). Some of the gold remains in the country with local goldsmiths who produce jewellery. Remarkably, miners typically receive at least 70% of the spot value of gold (unprecedented for almost any other commodity), illustrating the incredible ability of artisanal gold to transfer wealth directly from rich to poor even in very remote areas. Nonetheless, the more links there are in the supply chain, the lower the value ASG miners receive. Connecting miners more directly to markets leads to increased earnings and a level of supply chain transparency that promotes investment in better, low-mercury or mercury-free technology.



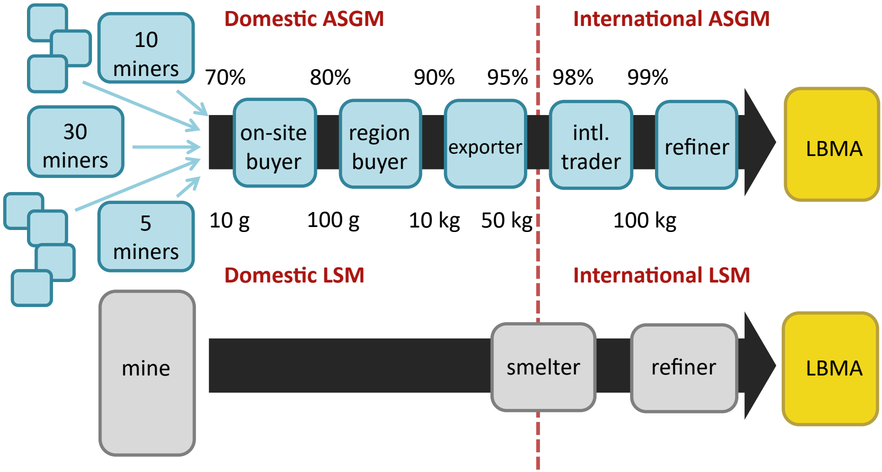


Figure 1-2. Schematic illustration of the ASGM and LSM gold supply chains. Moving from upstream to downstream, values are percent of the international spot price paid by the buyer and the aggregate amount of gold purchased at each level. Note that the gold supply chain of the ASGM sector is more structured than that of the large-scale mining (LSM) sector. The LSM supply chain typically does not involve local actors and little aggregation of quantities occurs before being sold into the international market, whereas ASGM gold passes through many series of buyers. ASM gold is often exported illegally before entering international markets. (LBMA = London Bullion Market Association).

Relevance

The supply chain provides information and constraints on gold production and so may be a valuable source of information for estimating mercury use. The many links in the supply chain are also many independent sources of valuable information about the ASGM sector. Gold traders can be secretive about quantities of gold purchased and mercury sold, however they can be a reliable source of more general information (*e.g.*, local/regional ASGM governance structure, site locations, technology, prices, and general gold/mercury trade routes) because they are a common hub in the ASG mining community.

1.10. Spatial Distribution

A country is divided spatially into several formal administrative units. From large to small these are often **country**, **state/province/district**, **county/district**, and **concession/mining title**. Overlaying the formal administrative structure is the informal structure of ASGM, for which spatial units can be defined as **ASGM regions**, **ASGM sites**, and **ASGM extraction** and **processing units** (**Figure 1-3**). ASGM sites comprise a cluster of extraction units (open pits, shafts), processing units (*e.g.*, sluices, panners, cyanidation plant), or both. Processing activity may be decentralized or centralized at a single location on the ASGM site or separate from the ASGM site (*e.g.*, in a nearby community). Miners may live on an ASGM site or in a nearby community. A single community may be situated between many ASGM sites, housing workers from each of them. An ASGM region typically encompasses numerous ASGM sites and can be coincident with formal state/ province/district/county boundaries or can be a separately defined zone. An ASGM region may have an access town that is a mining hub where regional trading of gold and mercury occur. An ASGM region or site may cross a country boundary.

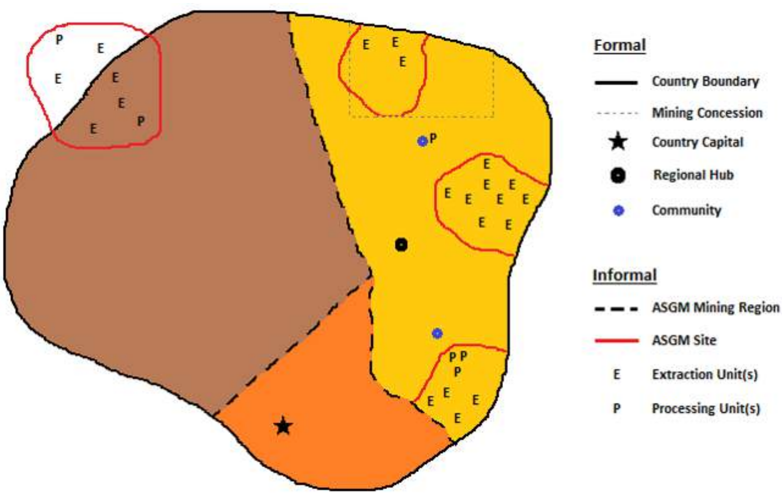


Figure 1-3. A generalization of formal and informal spatial units typically found in ASGM.

Relevance

Spatial information is a vital part of the NAP. Major mining regions are a basic unit involved in baseline estimates. Because ASGM practices can vary strongly between regions of the country, baseline estimates are first made at the regional level before summing into national values. Therefore, the major ASGM mining regions and sites must be identified before a plan can be made to collect field data. Observations on best/worst practices, health, and socioeconomic variables are also broken down by regions to allow NAP strategies to target locations in greatest need of intervention.

Note: To be effective in supporting strategy development, the NAP report should include a map of major mining regions and locations of ASGM mining and processing sites.

1.11. Seasonality

ASGM activity can vary greatly throughout the year, especially in regions that experience a heavy rainy season and seasonal flooding. During these times of the year, productivity and workforce, and thus mercury use may be drastically reduced.

Relevance

Annual mercury use and gold production are often calculated by interviewing about daily productivity. It is important for a researcher to ask clear questions about the seasonality of ASGM in the region so that productivity is not over- or under-estimated. For example, on ASGM Site A, a baseline team deduces that 1 kg of Hg is used per day. Miner interviews indicate they work 5 days per week and have 10 holidays per year (250 days of work per year). This could lead to the conclusion:

1 kg Hg/d x 250 d/y = 250 kg Hg/y

However, further questioning reveals that all extraction work stops for three months (~60 working days) each year due to flooding. There are now only 190 active mining days and the annual mercury use estimate for the site becomes:

1 kg Hg/d x 190 d/y = 190 kg Hg/y , 25% less than the first conclusion

1.12. Health Risks and Concerns

Health hazards in ASGM include mercury, cyanide, dust, and physical hazards. There are special considerations needed for women and children, who are more vulnerable to chemical exposure.

To learn more about the health hazards involved with ASGM, consult the following resources:

WHO, 2016. **Artisanal and small-scale gold mining and health. Technical paper 1: environmental and occupational health hazards associated with artisanal and small-scale gold mining.** Available at *http://www.who.int.*

Artisanal Gold Council, 2014. **Health issues in artisanal and small-scale gold mining: training for health professionals.** Available at *www. artisanalgold.org.*

1.13. Environmental Risks and Concerns

1.12.1. Mercury

Mercury has been recognised as a chemical of global concern because it can travel great distances through the atmosphere, bioaccumulate in ecosystems, and persist in the environment. There are two forms of mercury involved in ASGM releases and emissions to the environment: **elemental mercury** and **organic mercury** (also known as **methylmercury**).

Elemental mercury is released to land, surface water, and ground water as liquid and emitted to the air as vapour during ore processing, amalgam heating, and waste disposal. Under specific environmental conditions, elemental mercury can be converted to an organic form called methylmercury. **Methylmercury** bioaccumulates strongly, becoming more concentrated as it moves up the food chain. For example, as a predatory fish consumes many fish containing methylmercury, the methylmercury from all of its prey accumulates and reaches greater and greater levels in its body. People, who are higher yet in the food-chain, receive a high dose of mercury when they eat the predatory fish. The mercury accumulates in the body and at high enough levels may cause neurological damage and other adverse effects. The addition of cyanide to mercury (such as during cyanidation of mercury-contaminated tailings) accelerates the evasion of mercury to air and the dispersal of mercury throughout the aquatic environment. This is because cyanide-mercury complexes are water soluble and highly mobile in water. When cyanide-mercury complexes break down, the mercury released is readily transformed into methylmercury or evades to the air.

1.13.2. Sedimentation

When tailings enter a body of water from a processing unit like a sluice, an unnaturally high load of suspended sediments enters the body of water (**Figure 1-4**). This sedimentation may have the following adverse effects:

- increased turbidity (reduced light availability)
- loss of submerged vegetation & biota (reduced light availability)
- increased erosion
- circulation changes
- loss of coral reef communities
- watercourse alteration
- loss of sensitive aquatic habitat
- changes in nutrient balance
- changes in fish migration
- decreased fisheries resources
- loss of wetlands
- loss of recreation attributes

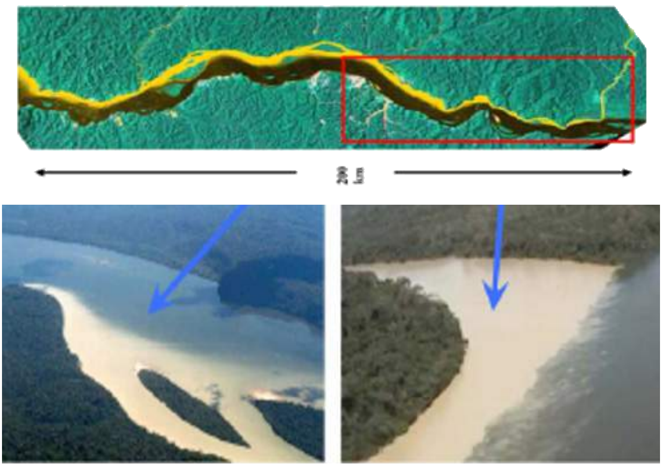


Figure 1-4. A false-colour Landsat satellite image and two aerial photos show the sedimentation caused by ASGM located on the Tapajos River, one of the largest tributaries of the Amazon River.

1.13.3. Waste Management

ASGM generally does not practice waste management or does so using substandard practices. This creates contaminated sites (**Figure 1-5**). Interventions, such as those of the AGC, and some countries, such as Ecuador and Mongolia, have begun to address this issue. Generally, the idea is to centralize waste management but to retain the existing decentralized and individualistic small scale socio-economic conditions vital to the ASGM community. Through the development of economically viable and formal processing operations, waste management systems (tailings disposal systems) become accessible and affordable for ASGM communities and their practices can then meet international standards.

Figure 1-5. Lack of deposit management during mining of alluvial gold in Kalimantan, Indonesia. Miners are burying the ore deposit in tailings, complicating further access to the ore. Poor deposit management causes rapid areal expansion (excessive land use, low land productivity) and loss of resources and natural habitat. It creates large areas of mercury emission to the air through evaporation and to the aquatic ecosystem through rainfall and flooding. It leaves a legacy that is difficult and expen-sive to remediate. It is avoidable.

1.13.4. Water Resources

ASGM processing can use large volumes of water, often without proper management or consideration of simple and profitable recycling. The demand on water resources can have negative impacts on surrounding communities that rely on the same rivers and aquifers for hygiene, drinking water, cooking, and agricultural needs, among others. There is also a risk of water contamination by mercury, cyanide, and acid generated from newly exposed sulphide minerals like pyrite in rocks – so called "acid rock drainage."

1.13.5 Land Alteration and Habitat Degradation

ASGM extraction in vegetated areas often requires forest clearing, which leads to degradation of the land, increased rainwater runoff, leaching and erosion of soils, and loss of habitat. Examples of significant land alteration by ASGM are the rainforest clearing conducted in Madre de Dios, Peru and Kalimantan, Indonesia.

Relevance

Including a breakdown of major health and environmental risks associated with the ASGM sector in the NAP helps to prioritize mitigation strategies to the regions that are most impacted by mercury use.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2. Introduction to ASGM Baseline

2.1. What is an ASGM Baseline?

In this guide, an ASGM baseline is tailored to the needs of the Minamata Convention, although it can surely serve other purposes. Annex C, Paragraph 1 (d) of the Minamata Convention requires that the National Action Plan (NAP) developed by applicable countries include ***"baseline estimates of the quantities of mercury used and the practices employed in artisanal and small-scale gold mining and processing."*** This is a fundamental axiom for countries with ASGM sectors that use mercury because the baseline estimate will inform all other decision making.

More specifically,

Mercury used: inventories of the amount of mercury used (lost to the environment) annually by the country's ASGM sector. These are the initial statistics about the sector that will form a starting point for monitoring change in mercury use, emissions, and exposure over time. As mercury reduction and elimination strategies are implemented in accordance with the Minamata Convention, new estimates will be compared with the baseline estimates to measure the effectiveness of the strategies in reducing mercury use and exposure.

Practices used: An overview of ASGM practices must be made for two reasons. First, the information in the overview is essential for developing research to determine the mercury used. Second, it informs the development of appropriate mitigation strategies for the NAP – ones that can be tailored to the realities of the ASGM sector in the country and targeted to the areas of greatest concern. The overview of practices is a detailed description of the country's ASGM sector, which includes, but is not limited to, information on the spatial distribution of activities, scale of production, mining and processing techniques practiced, governance, gold supply chain, and environmental and health concerns.

2.2. Why Carry Out ASGM Baseline?

Generating the ASGM baseline is a key early step in the NAP process. A baseline estimate of the quantity of mercury used and a comprehensive overview of ASGM practices allows a country to set realistic mercury reduction targets and timelines, and develop prioritized mercury reduction and monitoring strategies.

In this way, the NAP strategies are informed not only by an estimate of how much mercury is being used, but also where, by whom, and how, so realistic reduction targets, timelines, and required resources can be set.

Because the ASGM sector is complex and largely informal, measuring mercury use is difficult. This explains why there is not a strong global database of mercury use in ASGM yet. With this toolkit, estimates can be made that provide a level of information that is sufficient for developing strategies under the NAP.

2.3. What Information Needs to be Collected?

As described previously in *Section 2.1*, the information needs are guided by Annex C of the Minamata Convention and fall under two categories: (1) baseline estimates of ASGM mercury use and (2) an overview of ASGM practices.

2.3.1. Baseline Estimates of ASGM Mercury Use

The baseline must include:

Estimate of ASGM Mercury Use

The amount of mercury used (lost to the environment) annually by ASGM at a national scale and broken down by mining region.

Two key pieces of information that are not directly required under Annex C but are instrumental in calculating the mercury use estimate are:

Estimate of ASGM Gold Production

The amount of 24K (99.9% pure) gold produced annually by ASGM at a national scale and broken down by mining region.

Estimate of ASGM workforce

The total number of people in the ASGM workforce at a national scale and broken down by mining region.

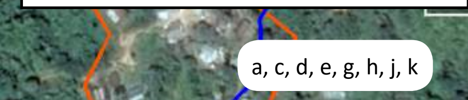
The information to produce these estimates is drawn from a combination of existing reports and new field based research.

2.3.2. Overview of ASGM Practices

The overview contributes information needed for all items in Annex C – listed on page *ii* of the forward material of this guidebook. Here, letters in white boxes correspond directly to the letters used in Annex C describing the required content of NAPs. An overview of ASGM practices can be broadly broken down into the following eight (8) aspects:

1. Distribution of Activity

- Location of ASGM regions, communities, sites, and relevant stakeholders (*e.g.*, gold traders).
- Location of formal, informal, legal, and illegal ASGM activity.
- Relative size and workforce of ASGM sites.
- Site accessibility (by road, boat, air, quality of the roads, travel time, security situation, *etc.*).
- Mining and processing practices used in each location.
- Areas ranked by mercury use, gold production, workforce, community population, proportion female/ youth/foreign workers.
- Locations of worst and best practices
- Data: Map(s) of the above, GPS coordinates, and descriptions.



a, c, d, e, g, h, j, k

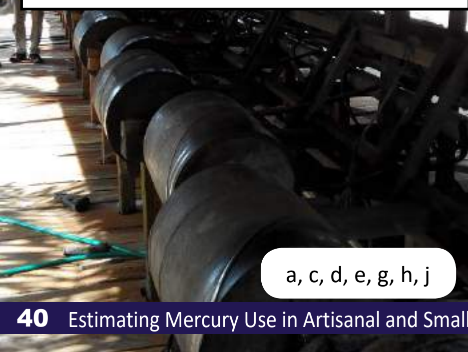
2. Governance

- What is the legal status of the sector? Formal or informal?
- How is the ASGM sector governed? (national, regional, community, and site-level) – An organizational chart.
- Who are the stakeholders?
- How are miners organized on the ASGM site?

a, c, d, e, g, h, j

5. Technology

- Is mercury used?
- What are the mining and processing methods used in each region of the country?
- What is the gold recovery for the various methods?
- Type and location of worst practices banned under Minamata
- Type and location of best practices (*e.g.*, mercury-free processing).



a, c, d, e, g, h, j

6. Socioeconomics, Health, and Environment

- ASGM workforce estimates.
- Gender breakdown of ASGM workers, communities, and leaders.
- Occupations/roles of men, women, and children.
- Observed health* and environmental* impacts of ASGM.

* *These are general observations and are intended to supplement, not replace, dedicated health, socioeconomic, and environment methodologies.*

e, g, h, i, j

3. Mineralogy

- What is the typical ore grade?
- What is the typical gold purity?
- What is the type of deposit being extracted? Hard rock or alluvial?
- Which minerals are present?

d, e

4. Gold & Mercury Trade

- How much gold is produced at a typical ASGM site?
- Where is the gold sold? What is the price?
- Where is the mercury bought? What is the price?

a, d, f

7. Knowledge Gaps

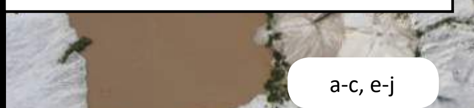
- Are there any regions of the country where very little or nothing has been documented on ASGM?

?

a, d, k

8. Priority Areas for NAP Strategies

- ASGM regions, sites, and processing units where mercury reduction efforts may have the greatest impact.
- ASGM regions, sites, and processing units where awareness-raising and information provision may have the greatest impact.
- Type and location of worst practices.
- Source and traders of mercury.
- What and where are the major health and environment risks and concerns concerning mercury? (as an additional indicator of areas where mercury use is high and where mercury reduction efforts may be most effective).



a-c, e-j

Table 1-1. Contributions of this toolkit to each of the requirements of the National Action Plan (NAP), which are elaborated on page *ii*.

	Requirement of the NAP	Contributing Aspect	Covered in this Guide
	National overview of ASGM sector		
(d)	Baseline estimates of the quantities of mercury used	Estimate of ASGM Mercury use Estimate of ASGM Gold Production Estimate of ASGM workforce	Y Y Y
(d)	Practices employed in ASGM mining and processing	Distribution of ASGM Activity Governance Gold and Mercury Trade Technology Knowledge gaps	Y Y[3] Y[3] Y Y[3]
(h)	Public health strategy	Socioeconomics, Health, & Environment Gold and Mercury Trade	N[1] Y[3]
(a)	National objectives and reduction targets	Estimate of ASGM Mercury use Estimate of ASGM Gold Production Estimate of ASGM workforce Technology	Y Y Y Y
(b)	Actions to eliminate worst practices	Distribution of ASGM Activity Technology Socioeconomics, Health, & Environment Priority areas for NAP strategies	Y Y N[1] N[2]
(c)	Steps to facilitate the formalization or regulation of the ASGM sector	Governance Gold and Mercury Trade Socioeconomics, Health, & Environment	Y[3] Y[3] N[1]
(e)	Strategies for promoting the reduction of emissions and releases of, and exposure to, mercury in ASG mining and processing, including mercury-free methods	Estimate of ASGM Mercury use Distribution of ASGM Activity Mineralogy Technology Priority areas for NAP strategies	Y Y Y Y N[2]

	Requirement of the NAP	Contributing Aspect	Covered in this Guide
(f)	Strategies for managing trade and preventing the diversion of mercury and mercury compounds from both foreign and domestic sources to use in ASGM	Governance Gold and Mercury Trade Socioeconomics, Health, & Environment	Y[3] Y[3] N[1]
(g)	Strategies for involving stakeholders in the implementation and continuing development of the NAP	Estimate of ASGM workforce Governance Priority areas for NAP strategies	Y Y[3] N[2]
(i)	Strategies to prevent exposure of vulnerable populations, particularly children and women of child-bearing age, especially pregnant women, to mercury used in ASGM	Distribution of ASGM Activity Technology Socioeconomics, Health, & Environment Priority areas for NAP strategies	Y Y N[1] N[2]
(j)	Strategies for providing information to artisanal and small-scale gold miners and affected communities	Estimate of ASGM workforce Governance Socioeconomics, Health, & Environment Priority areas for NAP strategies	Y Y[3] N[1] N[2]
(k)	A schedule for the implementation of the National Action Plan		N

[1] Covered in dedicated methodology documents, currently in development.
[2] Covered in the UNEP guidance document.
[3] Guidance on collecting data in support of this item is included in this guide but actions, steps, or strategies are to be made by the authors of the NAP.

1 Hire and train Baseline Team.

2 Conduct national ASGM sector scoping and regional visits.

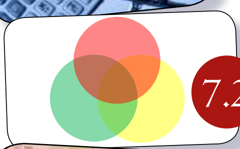
3 Make a country-specific research plan, select study sites.

4 Collect data in the field.

5 Record and analyse data and refine field methods.

6 Produce local information and averages of key variables from data.

7.1 Extrapolate local information to regional estimates.



7.2 Cross check regional estimates using several approaches, sources and reviewers.

8 Sum regional estimates to produce the national estimate.

2.4. How is an ASGM Baseline Conducted?

This section provides suggested steps for producing an overview of ASGM practices and baseline estimates of ASGM mercury use, gold production, and workforce.

In brief, after **hiring and traiing the baseline team**, **conduct national-level ASGM sector scoping** to identify existing information and gain an overall understanding of the ASGM sector. Identify the major ASGM mining regions.

Using the existing information, **design a research plan** with approaches to calculate estimates of ASGM mercury use, gold production, and workforce, in each region. Outline which information is needed and how it will be collected in the field. If all sites in a region cannot be visited, select a representative subset of ASGM sites.

Collect the required field data through direct observation, physical measurements, GPS, and interviews.

Use the data collected in the field, the approaches defined in the research plan, and the analysis tools provided in Annex A to **calculate key site-level variable averages and baseline estimates** for each site visited. Calculate using multiple approaches and cross-check the results to make sure they agree. If these statistics cannot be calculated due to bad data or data gaps, or estimates from different sources do not converge through cross checking, adjust the field approach for the next day to collect better data until the cross-check yields high confidence results.

Calculate baseline estimates for each region. If data are collected at all sites, sum all site-level baseline estimates. If data are collected at a subset of sites, extrapolate site-based information to a regional scale using relevant pieces of information about the region.

Cross-check regional estimates by triangulating the results of several approaches to create robust final regional estimates in which there is high confidence.

Determine national baseline estimates by summing the final estimates for all regions within the country.

Produce a final report with both a National Overview of ASGM Practices and a compliation of the site-level, regional, and national results of the baseline estimating approaches. This report will inform the development of NAP strategies.

3. National-level ASGM Sector Scoping

National-level sector scoping identifies existing information about ASGM in the country and provides a structured understanding of the sector. The existing information is used to (a) begin compiling the overview of ASGM practices; (b) identify which data is required to determine baseline estimates; and (c) plan approaches to collect the data in the field. A thorough sector scoping makes best use of the overall project time and improves the quality of the results. It allows the rest of the work to be optimized, done efficiently, and focussed where most needed. It identifies knowledge gaps that need to be filled and prevents the duplication of existing efforts. Developing a good picture of the sector based on existing information is particularly important for the field work; Being well informed in advance means better preparation, fewer adaptations, and fewer return trips to the field.

3.1. Sources of Existing Information

Compiling existing information is usually best done in a country's capital, where there is access to relevant government ministries, NGOs, and industry associations. Additional local information may be found only in regional or community government offices, in access towns (hub mining towns), on the internet, and in direct conversation with miners. Useful sources of information include:

3.1.1. Literature
3.1.2. Stakeholders
3.1.3. ASGM site visits
3.1.4. Aerial imagery

3.1.1. Literature

Information on a country's ASGM sector can be found in numerous types of literature and reports, from official government and trade documents, to "white papers" (published but not peer-reviewed documents) summarizing the research of funding agencies, NGOs, universities, and large-scale mining (LSM) companies, to peer-reviewed academic research papers. The literature review should include a legal and regulatory review of the laws and regulations surrounding the ASGM sector. **Table 1-2** lists some potential sources.

3.1.2. Stakeholders

Various stakeholders will have information to contribute. **Table 1-3** shows a list of common stakeholders and potential information. Refer to **Tables 4-1** and **4-2** of the UNE NAP Guidance Document for a more comprehensive list. Be mindful that some stakeholders may be secretive about certain topics, particularly those related to mercury use and illegal/informal ASGM activity. *Chapter 2, Section 4.3. Data Collection: Sequence of Locations and Tasks* describes interview approaches that address these challenges.

Table 1-2. List of typical literature sources of information on ASGM.

Source	Possible ASGM Information
Official government and trade data documents	Estimates of gold production, LSM & ASGM gold export, mercury import/export, population estimates, ASGM activity maps, and cadastral information on ASGM concessions/permits. Some examples of official documents are: national government reports, mining company reports, city hall/mayor's office registers, minerals yearbooks, commodities summaries, industry surveys, ASGM laws and regulations.
Project "white papers" (*e.g.*, GEF GOLD, World Bank, UN Agencies, Development Agencies, Universities, NGOs)	If previous ASGM baseline research or training has been conducted in the country, these reports may hold supporting information of various types and researcher and stakeholder contacts.
Peer-reviewed academic journal papers	If previous ASGM inventory, social development, health, geology *etc.*, research has been done in the country, these reports may hold supporting information of various types and researcher and stakeholder contacts.

Table 1-3. List of possible stakeholders and information they may hold.

Stakeholder	Possible ASGM Information	Comments
Ministry of Mines **Regional Mining Offices**	- Official records - Location of major ASGM regions - Number and location of ASGM extraction and processing sites - Total legal gold production (LSM and ASGM) - List of mining concession holders and contact information - Formal register or informal knowledge of number of ASG miners - Union/Association info and contacts - Map or knowledge of major mining regions/corridors (mining cadastre) - Mining legislation (legal policies related to ASGM activities, land and business ownership, taxation) - Mining code - List of registered gold shops & authorised buyers - Knowledge of ASGM research or development projects in the country	- Government information on ASGM can vary greatly from one country to another - Few countries have reliable estimates of miner population - Many mining ministries have some statistics on ASGM production. These are often low due to smuggling, but can give an idea of relative production by region - Check if there is an ASGM licensing system in place - Some ministries license larger ASGM operations to use machinery (mills, dredges, pumps, concentrators). These can serve to indicate production or activity levels where other statistics are lacking - Ministries may have local branches within or nearby ASGM regions. These local branches may have further information on local ASGM sector
Ministry of Environment **Ministry of Forests** **Regional Environment Office**	- Same as previous	- Often responsible for giving environmental licenses to ASG miners – an important source of information about the sector - May provide information on location of ASGM sites and environmental impacts of the sector.
Local/ Community/ District offices **Community Leaders**	- Same as previous, but locality/ community-based - Knowledge of formal or informal ASGM governance structure and/or taxation	- May have information on ASGM activity in the locality. In some countries, these offices take charge of informally regulating the ASGM sector.
Gold Buyers, traders, and/or exporters	- ASGM practices and regulations - Location of ASGM sites & relative production - Amount of gold bought and/or exported - Gold purity - Buying and selling price of gold - Buying and selling prices of mercury - Reference for gold and mercury prices - Who buying/selling gold and mercury to/from	- May be informal or formal entities. Some countries have official government gold buying entities - Gold buyers or exporters in the capital often know which regions are producing and may have at least an idea of their production levels – although this type of information needs to be evaluated carefully - should also know whether a region produces sponge gold (gold amalgamated with mercury) or powder/ flake gold (which can imply mercury-free processing, but not always) - Note: gold traders may be hesitant to share details about operations and may even provide false data.

Stakeholder	Possible ASGM Information	Comments
NGOs	- Existing ASGM projects - Existing ASGM data - Location of ASGM sites & relative activity levels - Knowledge of formal or informal ASGM governance structure and/or taxation - Stakeholder contacts	- NGOs that work with or study ASGM will often have data on areas of exploitation - NGOs may also have data on local politics, numbers of miners, or their environmental impact, or other relevant information
Miners Organisations **Miners Groups** **Miners Unions** **Mining Cooperatives**	- Existing ASGM projects - Knowledge of miners' organisations - Number of registered members - Main issues in the sector - Typical miner wages - Typical operational hours/shifts/days - Types of mining and processing - Organisation of miners *(land owner, crew boss, groups of miners or individuals?)* - Location of major ASGM regions - Number and location of ASGM extraction and processing sites	- In some countries, ASG miners have a lobbying or trade association in the capital and/or key mining regions. This association can provide information about its membership and where and how they work.
Large Scale Mining (LSM) Companies	- Name and location of LSM sites - Gold production on LSM sites - Typical ore grade range - Map or knowledge of major mining regions/corridors - Reserves - ASGM presence on the LSM concession - ASGM research conducted by the company - Possible processing services provided to ASG miners - History of conflict with ASGM, if any	- LSM companies operating in certain mining regions may have completed studies of ASGM within their concessions and may have a variety of information on the sector. - In certain cases, LSM may provide processing services, such as a cyanidation centre to the ASG miners for a fee.
Customs Office – National and Regional	- ASGM gold trade regulations - Mercury trade data: import/export quantities and source/destination - Gold trade data: import/export quantities (ASGM & LSM) and source/destination - Proportion of total gold trade accounted for by ASGM	- Trade data on mercury and ASGM gold is often coarse and/or speculative, especially if these trades are illegal.
Donor Agencies (*e.g.*, GEF GOLD) and World Bank	- Past and present relevant projects in the country - Existing data, reports, project sites and other related information - Stakeholder contacts	- Have there been assistance projects that focused on or included major components related to the ASGM sector? Is there any available literature or a point of contact for this research?
UN Environment Global Mercury Partnership (GMP)	- Past and present relevant projects - Existing data, reports, project sites - ASGM rguides and esources - Stakeholder contacts	- Has any inventory research or training been conducted in this country? Is there any available literature or a point of contact for this research?

3.1.3. ASGM Sites

Often overlooked, valuable information can be found on ASGM sites. **Table 1-4** shows a list of information that may be collected at ASGM sites. At the scoping stage, the team should visit one or two ASGM sites to form a general understanding of the practices used, what type of information can be gathered, and strategies to collect the information. The Baseline Team will return to the ASGM sites at a later date to gather the information in detail via observations, counts, physical measurements, and interviews with miners.

Table 1-4. List of ASGM sites and information that may be collected from each.

Source	Possible ASGM Information
Extraction sites	Ore extraction information, number of miners and mining units, ore grade, gold purity, number of active extraction days per year.
Processing sites	Typical daily throughput of a type of processing unit, number of operators per unit, number of units, ore grade, gold purity, gold recovery, number of active processing days per year, mercury use, mercury recovery.
All sites	Average income, price of gold, distribution of revenue, miner population, total gold production, number of active days per year.
Gold traders	Buying and selling price of gold, source of price, where gold is sold to, typical gold purity, amount of gold bought, amount of mercury bought and sold, buying/selling price of mercury, source and destination of mercury, total number of gold traders on site.

3.1.4. Aerial Imagery

Aerial imagery includes satellite images, air photos, and photographs taken by drones or other unmanned aerial vehicles (UAVs). These images offer a birds-eye view that can be used to detect ASGM activities. Signs of ASGM activity that may be visible in aerial imagery are bags of ore, processing operations, disposed tailings, deforestation, river siltation, and built structures (camps). This approach is particularly useful when gathering information about remote areas or in difficult-to-access conflict zones where accessibility challenges have limited previous scoping. Aerial imagery will work best for areas where there is low forest cover, such as riverside alluvial operations, deforested areas, and arid and high elevation regions. Satellite imagery can be found via free sources such as Google Earth and the Landsat satellite archive. Government agencies may have air photos in their archives. Drone photos may have been taken by government agencies, NGOs, or LSM. **Table 1-5** shows a list of sources where free aerial imagery might be found.

Table 1-5. List of providers of free aerial imagery (satellite and air photos).

Source	Possible ASGM Information
Google Earth Pro USGS Earth Explorer ESA Sentinel Data Hub NASA Earth Data Search Earth Observation Link (EOLi) INPE Image Catalog Bhuvan Indian Geo-Platform Global Landcover Facility CNES THEIA Land Data National, Community & University Libraries	Satellite images and air photos for detecting signs of ASGM activity: tailings disposal piles, deforestation, river siltation, and remote camps.

4. Research Plan and Study Sites

As Annex C (d) of the Minamata Convention states, a key task for a country developing a NAP is to develop a *"baseline estimate of the quantity of mercury used and the practices employed in artisanal and small-scale gold mining and processing within its territory."*

The phrase 'within its territory' obviously means all of a nation's territory. However, for larger or geographically diverse nations this can clearly pose a challenge: Which regions to visit? Which sites to inspect and measure? How many sites to measure? How much time and how many resources are available to complete the task?

The baseline team addresses these questions by creating a **baseline research plan**. The baseline research plan identifies approaches for estimating mercury use that are appropriate for each major ASGM region. Approaches are selected in regard to (1) the technology and practices used in ASGM mining and processing in the region; (2) the accessibility or remoteness of the ASGM sites; and (3) the availability and extent of existing data available. It outlines where (which ASGM sites and stakeholders) and how (data collection methods) to deploy available resources to find robust and accurate baseline estimates.

4.1. Allocating Resources

The question of time and resources is particularly important. Countries will decide to allocate NAP resources in different ways. Resources are finite and so (usually) not every site can be visited. The national baseline estimate must fit within the envelope of resources dedicated to the task while recognizing that it is one of the most critical information needs for developing a NAP.

4.2. Selecting Study Sites

The site selection must encompass the scale and distribution of ASGM activities, the accessibility of ASGM sites, the size of the field team, the timeline, and the financial resources available. The key goal when selecting a subset of sites is to capture the diversity of ASGM practices and productivity in the region.

When selecting sites, the key questions that the research team must ask are:

Where is ASGM activity concentrated?
In which general areas are the greatest mercury use, gold production, and miner populations found? Be sure to visit these sites of greatest ASGM productivity, earnings and mercury use. Note: some smaller sites need to be visited as well. When extrapolating to a national scale, information from large sites may not be applicable to small sites and vice versa.

Where are the different mining and processing technologies located?
Which sites have ASGM methods and practices that reflect the full range of ASGM practices found in the region? These will be priority sites because they capture the full range of technologies in one site visit.

What and where are the knowledge gaps? Prioritize these. In what regions are new field data required to fill knowledge gaps? Knowledge gaps are ASGM regions or practices for which little is known after conducting national-level scoping.

5. Collecting Data in the Field

This section discusses how data is collected in the field. It describes the tools and methods that are available to gather data and assess data quality.

5.1. Sources of Field Data

Refer to *Tables 1-3* and *1-4* of *Section 3.1 (pp. 48-50)* and also to the UNE NAP guidance document for a list of potential data sources and data types.

5.2. Techniques for Collecting Data in the Field

5.2.1. Conducting Interviews
5.2.2. Using Direct Observation, Counts, and Physical Measurments
5.2.3. Collecting Spatial Information
5.2.4. Observing and Analysing Aerial Imagery

5.2.1. Interviews

Interview stakeholders to gain insight into ASGM operations; to collect information to crosscheck field measurements; and to identify further stakeholder contacts. For interviews to yield good results, researchers must build trust with interviewees by explaining the project objectives and demonstrating her or his knowledge of the sector. **Remember, it is a conversation!**

Interviewing with Field Forms

Information on ASGM comes primarily from observation and interviews. An essential tool for documenting this information is the field form. Field forms provide a place to store the information gathered in the field. They should also help to guide interviews and to remind researchers of anything they may have forgotten to ask. The information can be recorded directly onto the form, or can be written in a notebook and transcribed onto the form later.

Important note: An over-reliance on forms can create problems. Pulling out a form and asking questions one by one can be off-putting and may give an interview the feel of an interrogation or bureaucratic exercise, with which the interviewee may become bored or uncooperative. A good field interview is like a conversation, with questions and answers on one topic leading naturally to another. Another risk in over-reliance on forms is that, because there is great variety between ASGM sites, reliance on a single standard form may cause important data to be missed.

*** Field forms can be found in Annex A1. These forms are specific to stakeholder and location.**

Interviews with Miners: Starting the Conversation

A good interview may start off with a few unthreatening and unimportant questions just to put the interviewee at ease and get them talking. An example might be, "***How is the mining going this week?***" or "***Where are you from?***" or "***How long have you been a miner?***" The answers are not really important, but they start the conversation.

As the interview progresses, proceed to the important questions. These are often the questions on the form. But, there should be no need to pull out the form and read off the questions. Glance at the form as the interview progresses to check that all the important topics have been covered. Ask questions in a natural voice and do not read off the sheet. After each question, listen and write down the answers, and then ask follow-up questions to bring out more information. The information can be recorded directly onto the form, or can be written in a notebook and transcribed onto the form later.

Ask a variety of questions that lead to the same answers and record the information from each question. This allows for cross checking of the information to ensure it is not contradictory, and to make sure the miner is providing real information and not making up answers.

Evaluate the credibility of the miner based on their opportunity for direct contact with/knowledge of the sector.

Good researchers:

- have read or been briefed on the baseline research plan and fully understand what is to be accomplished (*i.e.*, the purpose of their data collection and how it will fit into calculations of gold production, mercury use and workforce);
- are educated about ASGM practices and unique characteristics of the various ASGM regions;
- have studied the forms, memorized most of the questions, and know what information they need to gather;
- can adapt interview questions quickly to suit the characteristics of the site and to provide cross-checks of information as it is received.
- These techniques take practice to become second nature. It is a good idea for interview techniques to be practiced as part of training before going into the field.

5.2.2. Direct Observation, Counts, and Physical Measurements

Stakeholders may or may not be willing to share information on mercury use and gold production. Even if willing, the information provided may have variable accuracy as miners have varying levels of understanding of ASGM methods. Direct observations, counts, and physical measurements are thus instrumental in gathering and cross-checking data.

Observations

Observation enables the team to understand ASGM practices and socioeconomic facets (*e.g.*, methods, productivity, throughput, gold production, mercury use, roles of gender and youth). Also, to quantify mercury use and cross-check reported values, direct observation of an entire processing method is needed.

Example: Researchers can rotate shifts to achieve 24-hours of continuous observation on a specific extraction or processing unit, gathering information about processing method, throughpout, recoverable grade, gold production, mercury use, *etc*.

Counts

Simple counting can be used to find important information. For example, you may count the number of bags of ore that pass through a mill per hour, the miners in each pit, and the operators working on each processing unit. These counts can be used to estimate daily throughput, miner workforce, and processor workforce, respectively. Counting the ASGM sites in a region or the active extraction or processing units on a site lends information for region- and site-level extrapolation of estimates.

Example: Hire a local miner[1] who is knowledgeable about the ASGM region and transportation. Visit and count all the ASGM sites in the region (if small) and perhaps even get counts of miners, processors, and units.

Counting the number of active open pits on an extraction site and the number of bags of ore produced at each pit to form an average of production per pit.

[1] It will not always be able to choose who is assisting in infomation collection. For example, the local government mining representative may insist on taking you to the sites. You should be prepared for these scenarios, be aware of any data biases that could result, and come up with ways to address/correct the biases.

Weight (Mass)

Ore Production & Throughput:

Miner estimates of the weight of a sack of ore can be far off. To cross-check, several sacks of ore can be weighed and averaged. This average weight will help to determine ore production rates and the throughputs of processing units.

Example: Weigh a sack of ore on a bathroom scale. Be aware of the capacity of the scale! Some bags can weigh up to 200 kg. Split the sack of ore into weighable portions if necessary. If a scale is not available, estimate by balancing multiple sacks against a person of known weight on a plank.

Mercury use:

The quantity of mercury entering and mercury and gold recovered from a processing unit can be weighed to determine the total amount of mercury used per gold produced (method in *7.4.2. Mercury-to-Gold Ratio, p. 73*).

Example: Weigh mercury and sponge gold in a container on a high-precision scale (at least two decimal places).

Volume

Water use:

The rate of water used by a processing unit (*e.g.*, sluice) can be found by measuring the volume of water entering or exiting the unit over a set time.

Example: Volume of water measured with a vessel of known volume (basin, jar, jug, soda bottle, *etc*.).

Mercury use:

Volume measurements can be used together with the known density of mercury to determine mercury use, however volume measurement is typically less accurate than weight.

Example: Measure volume of mercury with syringe or graduated cylinder.

5.2.3. Spatial Information

Spatial information on ASGM is particularly useful in identifying areas of highest priority to target NAP strategies (*e.g.*, areas of worst practices, greatest mercury use, and greatest workforce). The spatial information of primary interest in the NAP is the breakdown of national ASGM mercury use estimates into major mining regions. Other pertinent spatial information includes the locations and extents of specific ASGM practices, extraction and processing sites, communities, gold traders, tailings disposal areas, and other sites of interest.

Example: A GPS unit or mobile phone can be used to record coordinates. Participatory mapping, where knowledgeable stakeholders indicate locations of ASGM activity on digital or paper maps, is an effective method of understanding the sector at a glance. GIS software (*e.g.*, ArcGIS, QGIS) can be used to upload or digitize, store, and display this information on maps, or overlay with additional information such as aerial imagery and boundaries of districts/states/provinces, concessions, and protected areas.

5.2.4. Aerial Imagery

If available, satellite and air photos can be used to gather spatial information about ASGM sites, such as extent, distribution, accessibility, land use, and tailings management (see previous section, *3.1.4, p. 51*).

An aerial photo of an ASGM site taken from an aircraft. A similar photo could also be taken with a drone.

This false-colour image taken by the Landsat satellite shows siltation from alluvial ASGM sites along the Tapajos River, Brasil, which is a major tributary of the Amazon River.

5.3. Assessing Data Quality

5.3.1. Assessing Data Quality During an Interview

It should be noted that not all interviewees will yield accurate information sufficient for producing baseline estimates. It is at the researcher's discretion to determine which information is trustworthy and valuable. Cross-checking information quickly in the field by asking the same questions to different miners, or even to the same miner in different ways, can provide valuable hints about the accuracy of information given. For example, to determine the amount of ore processed per day you might ask:

Q. How much ore do you process in a day? A. 1 tonne
Q. How many bags of ore do you process in a day? A. 15
Q. How much does a bag of ore weigh? A. 100 kg

A simple calculation (100 kg x 15 bags = 1500 kg or 1.5 tonnes) will show that the information does not agree, and the baseline researcher would have to dig further to determine which, if either, line of information is correct and usable. At the end of the collection period, the surveyors must assess the information and determine which data to include when producing baseline estimates.

5.3.2. Assessing Data Quality Daily

At the end of each field day, or the following morning before departure to the field, the researchers should review their data from the field. Using the data, the team should attempt to calculate key site-level variable averages (*e.g.*, ore extraction per miner, miners per extraction unit) and estimates of workforce, gold production, and mercury-use. Confidence in the variables and estimates should be evaluated by cross-checking with multiple methods and by ensuring values make sense through a geological lens, income lens, and general knowledge of the sector. These daily calculations ensure that all data have been collected or, alternatively, show that data have been missed and how data collection can be adapted to yield better data the next day.

A Note on Quality

Ultimately, the Baseline Team is responsible for the quality of the ASGM baseline estimates. Team members need to comprehend and collect thoughtful, relevant and high-quality data that involves significant financial, time, and opportunity costs. Advice and feedback from external reviewers, experts, or technical tools such as guides and instructions are helpful aides, but the achievement of good results falls on the individuals carrying out data collection. For this reason, one of the biggest determinants of success is a capable Baseline Team.

5.4. Tools for Collecting Data in the Field

The Baseline Team should consider bringing the following equipment with them in the field. Having a pre-departure checklist will ensure that the field kit is complete before entering the field.

Supplementary tools for collecting field data are found in Annex A. These tools include printable field forms, scoping templates, Excel workbooks for recording and analysing data, common equations, and example calculations.

ASGM Site: Korfalo | Location Information

ASGM Site	**Korfalo**	Associted Communities	Kafala
Concession/Mining Title	-	County / District	Malika District
ASGM Mining Region	Godu	Province / State / Depertment	Godu Province
Lat	1.216667	Country	Goldaguay
Long	123.500000		
GPS device & datum	Trimble handheld GPS, NAD83		
Date(s) of data collection	Oct 30, 2017	Name of field researcher	Marie Cooke

Site contact(s): name	Ana Fleur	Eli Strong	Jim Jones	
role	Community Chief	Mining Coordinator	Cooperative Leader	
phone number	1(234)567-1234	1(234)567-8910		
email			jjones@email.com	

6. Where to Go, Who to See

Determining ASGM baseline estimates involves visiting sites where artisanal mining takes place to interview government officials, gold buyers, gold miners and others. Many such missions to many or most of the artisanal mining sites in a country will be necessary to develop accurate estimates of mercury use.

A research mission into a region should visit all the common research destinations shown in **Figure 1-6**, interviewing a different set of informants in each. Circumstances may vary; a country may not have all these locations, a team may not be able to visit all these locations, or may choose to visit several of a location (several gold traders or communities, for example).

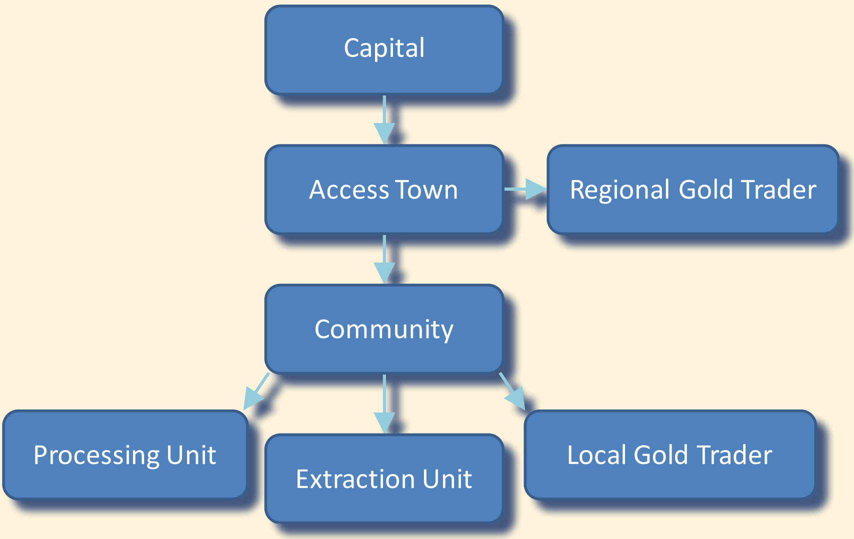
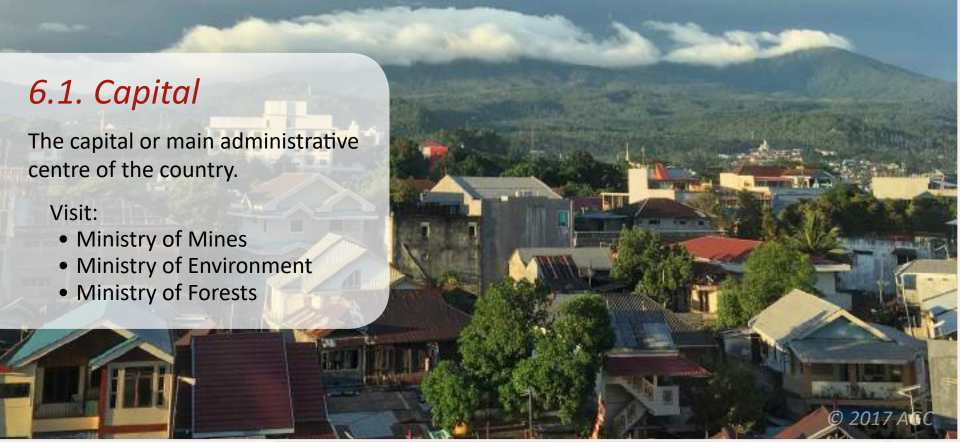


Figure 1-6. Places to visit when conducting ASGM baseline research.

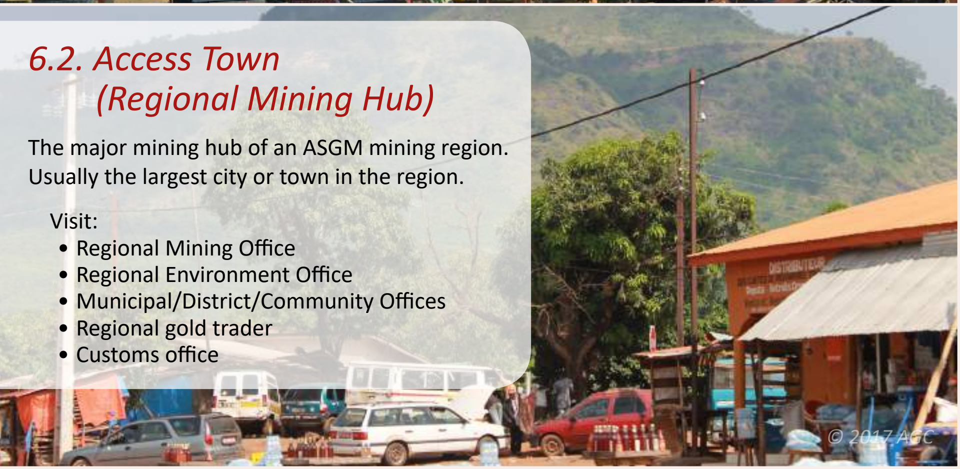


6.1. Capital

The capital or main administrative centre of the country.

Visit:

- Ministry of Mines
- Ministry of Environment
- Ministry of Forests



6.2. Access Town (Regional Mining Hub)

The major mining hub of an ASGM mining region. Usually the largest city or town in the region.

Visit:

- Regional Mining Office
- Regional Environment Office
- Municipal/District/Community Offices
- Regional gold trader
- Customs office

6.3. Community

The community (or mining camp(s)) in or near an ASGM site. This is where miners and their families live, and is often the site of a thriving secondary economy.

Visit:

- District/Community Offices
- Community leader
- Cooperative leader
- Concession owners
- Processing centre owners
- Miners
- Local gold traders

6.4. Gold Traders

Gold traders can be found in the regional mining hubs, communities, and directly on ASGM sites. They purchase gold from miners and sell to larger-scale buyers in the region/capital, or export the gold legally or legally. Traders can give you an idea of the amount of gold transiting a region or site. Gold traders are sometimes involved in the mercury trade and can be a source of information about quantity, source, and destination of mercury. Gold traders may be hesitant to share details about operations and may even provide false data, especially if the ASGM is informal, or if the mercury trade is illegal. Some gold traders vaporise amalgam on their premise, and may also conduct smelting and coarse refining.

6.5. ASGM Site

A group of mining and/or processing units where miners are working.

Visit:

- Extraction/processing workers
- Extraction/processing bosses
- Concession owners
- Ore transport workers
- Mining coordinators
- Cooperative president/ members
- Local gold traders

Extraction Unit:

The location from which ore is extracted, it is the most basic unit of extraction work operating on a site. Examples of extraction units: a group of miners in an open pit, shaft, or tunnel; a group of surficial material miners.

Processing Unit:

The location where ore is processed to extract gold. It is the most basic unit of processing work operating on a site. May include crushing, milling, concentrating, amalgamation, amalgam vaporizing, cyanidation, or others. It may be a set of individual processing components operating together (*e.g.*, crusher plus a set of mills), or it could be defined at a finer scale (*e.g.*, one mill or one sluice or one panner). The processing must be defined at the outset.

7. Approaches for Estimating Mercury Use

There are many possible approaches for estimating ASGM mercury use. The team should apply as many approaches as possible and triangulate (compare) the results to increase confidence in the final estimate. Here are four categories for estimating mercury use:

1. Consult official mercury trade documents
2. Interview mercury sellers
3. Interview mercury users (processing centre workers and owners)
4. Estimate gold production and apply a mercury-to-gold ratio (Hg:Au)

Some of these categories house multiple approaches. Each category will be described in greater detail in the following subsections. Note that approaches are not limited to the options listed in this section. ASGM scenarios differ greatly between countries and between the regions within a country. Therefore ingenuity is instrumental in defining suitable approaches.

7.1. Consult Official Mercury Trade Documents

This will often only be a coarse and dated estimate if the mercury trade is now illegal. However, the statistic may be a useful starting point for means of comparison with other approaches.

7.2. Interview Mercury Sellers

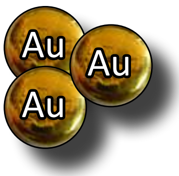
If mercury sellers can be located, ask how much mercury he/she sells every week and/or month. Also ask how many other mercury sellers are active on the site. Multiply the two figures. This will be a coarse estimate due to the illegal, and thus secretive, nature of the trade, but is a useful starting point for means of comparison with other approaches. Be mindful that a mercury seller could be anyone. For instance, a gold trader, business owner, member of the community, or even a community leader might be involved in mercury trade.

7.3. Interview Mercury Users

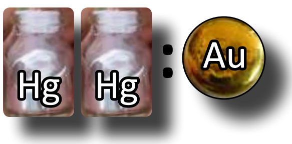
Ask processing centre owners and workers how much mercury they buy every week and/or month to replace what they have used. This will be a coarse estimate, but is a useful starting point for triangulation.

7.4. Estimate Gold Production and Apply a Mercury-to-Gold Ratio

If the following two statistics are known for a specific unit or region (extraction unit, processing unit, ASGM site, region, or country), it is possible to estimate mercury use for that unit or region.

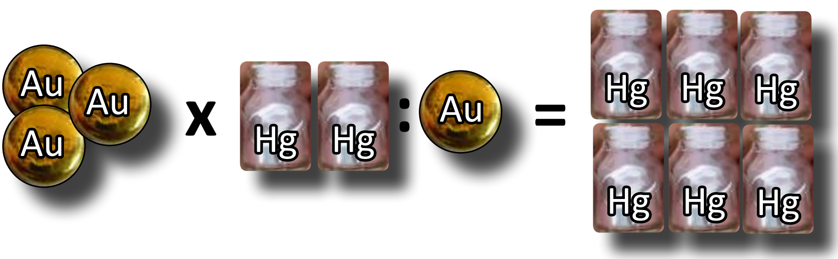


Gold Production: Amount of pure (24K/100%) gold produced in a specific amount of time (*e.g.*, grams of gold produced annually)



Mercury-to-Gold Ratio: The typical amount of mercury, in grams, used to produce one gram of that gold. This ratio is specific to the processing method used to produce the gold. See *Section 7.4.2* of this chapter *(p. 73)* to learn how to calculate this ratio.

Multiplying the two numbers will yield an estimate of the amount of mercury that was used to produce that gold.



Gold Produced

Hg:Au Ratio

Mercury Used

7.4.1. Estimating Gold Production

When estimating mercury use with gold production and a Hg:Au ratio, there are many ways to estimate the gold production. Here are seven possible approaches:

1. **Official Trade Data:** Official government documents sourced at the capital may provide one estimate of gold production for the country and/or regions.

2. **Stakeholder Interviews:** Interviews with various stakeholders (*e.g.*, government mining office officials, LSM, local administrator, community leader, mining coordinator) may provide another estimate of a mining region's weekly, monthly, or annual gold production.

3. **Gold Trader Interviews:** The gold purchased weekly/monthly/annually by regional and site-based gold traders may provide an estimate of the gold produced by ASGM in a region.

4. **Ore Transport Data (interviews and observation):** Interviews with ore transport workers or direct observation of ore transport volume may provide an idea of ore production. Combine the ore production with typical ore grade, gold purity, number and schedule of transport workers to get an estimate of gold production.

5. **Extraction Data (interviews and observation):** Interviews about extraction units (open pits/shafts) can provide an estimate of how much gold gets produced per unit, site, or region.

6. **Processing Data (interviews and observation):** Interviews about processing units can provide an estimate of how much gold is produced by each processing unit or site.

7. **Earnings Data (interviews):** Interviews with stakeholders (extraction and processing workers, group bosses, mining coordinators, mine/land/concession owners, cooperative leader and members, community leader, gold traders, *etc.*) can yield an estimate of the revenue distribution between stakeholders and the number of each stakeholder. Combining these two gives an estimate of total gold production per extraction/processing unit or site.

Approaches 1 through 4 offer very coarse estimates of gold production because government records are often incomplete and requesting a large-scale and complicated estimate from interviewees is certain to produce a wide range of responses.

Approaches 5 through 7 (calculations based on extraction, processing, and earnings information) can yield more rigorous estimates of gold production because they involve hard data that is cross-checked through multiple sources. For all three of these approaches, the general sequence of steps is the same:

Step 1: Collect information on sites relating to extraction, processing, or earnings through sector scoping, stakeholder interview, and physical measurements in the field. This site-level information will lend an idea of the amount of gold produced in the region annually.

Step 2: Using physical measurements of mercury on processing units, determine the average Hg:Au ratio(s) for the method(s) that produced this gold, noting how this ratio varies.

Step 3: Multiply the annual gold production by the Hg:Au ratio to get annual mercury used.

The following sub-sections, describe the extraction-, processing-, and earnings-based approaches for estimating ASGM gold production on an ASGM site.

Note: These approaches can also yield estimates of workforce for inclusion in the ***Overview of ASGM Practices.***

Extraction-Based Estimates of Gold Production

An extraction-based approach uses information collected about ore extraction to produce estimates of ASGM gold production and workforce. To carry out this approach, the baseline team must gather information about the number and type of extraction units in the region, the typical ore production per extraction unit or miner, and the number of extraction units or miners per site.

Where to collect data on site: Site leaders, group leaders, mining bosses, pit bosses, extraction workers, transportation workers.

Where to collect data off-site: Gold buyers/trade rs, site-level stakeholders, National Level ASGM Sector Scoping Report.

Data collected on each select extraction site:

- Number of miners working in an extraction unit
- Number of active extraction units on the extraction site
- Number of active extraction days per year (d/yr)
- Number of shifts per day and average shift length for an extraction worker
- Daily ore production rates (kg/d)
- Average ore grade (g/T) and gold purity (%)
- Processing methids on site and relative throughput/production of each, so that the correct Hg:Au ratios can be applied to each type and the mercury use calculated at the correct proportion.

Site-specific variables calculated from the site data:

- Total number of miners on the extraction site
- Daily ore and gold production per extraction unit (T or g/unit/d)
- Daily ore and gold production per miner (T or g/unit/d)
- Daily ore and gold production for the site (T or g/site/d)

* Annex A4 provides equations that can be used to calculate site-specific variables.

Processing-based Estimates of Gold Production

A processing-based approach uses information collected about ore processing to produce estimates of ASGM gold production, mercury use, and workforce. To carry out this approach, the baseline team must gather information about the number and type of processing units in the region, the typical throughput of each processing unit, and the number of processing units per site.

Where to collect data on site: Site leaders, group leaders, processor bosses, processors/processing unit operators.

Where to collect data off-site: Gold buyers/traders, site-level stakeholders, National Level ASGM Sector Scoping Report.

Data collected on each select processing site:

- Number of workers on a processing unit per shift (workers/unit/shift)
- Number of active processing units on the site
- Daily ore throughput of each processing unit (T/unit/d)
- Number of active processing days per year (d/yr)
- Number of shifts per day and average shift length for a processing worker
- Average ore grade (g/T) and gold purity (%)
- Gold produced per processing unit per processing cycle (g)
- Note: "processing cycle" is the interval from ore input to gold output.
- Mercury used and recovered per processing unit per processing cycle (g)

Site-specific variables calculated from the site data:

- Number of processing workers on the site
- Gold produced per cycle and day for a processing unit (g/unit/cycle or d)
- Gold produced per day for the site (g/site/d)
- Mercury used per cycle and day for a processing unit (g/unit/cycle or d)
- Mercury used per day for the site (g/site/d)
- Hg:Au ratio for each processing method

* Annex A4 provides equations that can be used to calculate site-specific variables.

Earnings-based Estimates of Gold Production

An earnings-based approach uses information collected about stakeholder income to produce an estimate of ASGM gold production or workforce. To carry out this approach, the baseline team must gather information about the distribution of revenue between stakeholders for a specific venture (extraction/processing unit, business, ASGM site), and the number of a certain type of stakeholder (*e.g.*, extraction workers or mine owners) to produce an estimate of total earnings. If earnings are reported in grams of gold, then the estimate of gold production is known. If it is in local currency, an understanding of average gold purity will yield gold production.

*Important note: The total daily and annual earnings per site and the revenue distribution (marked with an * below) are difficult to find with accuracy and for that reason, this method is less accurate than the extraction and processing-based methods. It is, however an important means of cross-checking production.*

Where to collect data on site: Site leaders, group leaders, processor bosses, processors/processing unit operators, land owners, business owners, co-op directors.

Where to collect data off-site: Gold buyers/traders, site-level stakeholders, National Level ASGM Sector Scoping Report.

Data collected on each select mining or processing site:

- Total daily and annual earnings per site*
- Revenue distribution*
- Average gold purity (%)

Site-specific variables calculated from site data:

- Daily & annual ore production for the site (T/site/d)
- Daily & annual gold production for the site (g/site/d)
- Daily & annual mercury use for the site (g/site/d)
- Total miner population

* Annex A4 provides equations that can be used to calculate site-specific variables.

7.4.2. Mercury-to-Gold (Hg:Au) Ratio

Once gold production has been estimated, the next step is to find out how many grams of mercury are typically used to produce each gram of that gold. This is expressed the mercury-to-gold (Hg:Au) ratio.

Hg:Au Ratio: the grams of mercury used (lost to the environment) in producing one gram of gold.

The Hg:Au ratio is specific to the type of processing used.

7.4.3. Where Does a Hg:Au Ratio Come From?

A Hg:Au ratio must be **measured**. To produce a Hg:Au ratio for a processing unit, the mass of mercury entering and leaving the processing system must be measured in two phases of processing: the mix phase and heating phase.

Mix phase:

a) Weigh the liquid mercury added to the ore before mix.
b) Weigh the mercury recovered from the ore after mix (contains recovered liquid mercury and the amalgam).
c) Weigh liquid mercury remaining after squeezing to retrieve the amalgam.

Heating phase:

d) Weigh the amalgam before heating.
e) Weigh the sponge gold after heating.
f) Weigh the mercury recovered by the retort (if present).

Hg:Au ratio calculation:

1. Convert the weight of the sponge gold into equivalent mass of pure* (24K, 100%) gold using the average reported gold purity on site *(p. 5)*.
2. Calculate the total mercury used by subtracting the mercury recovered by squeeze and by retort from the mercury added to the ore.
3. Divide the total mercury used by the mass of pure gold produced.

Hg:Au ratio = (Total Hg used) / (mass of sponge gold produced)

Detailed directions for how to measure these variables on a processing unit are found on *p. 124.*

7.4.4. Many Hg:Au Ratios: One Per Processing Method

An important thing to note is that the Hg:Au ratio will vary from one form of processing to another. For instance, concentrate amalgamation is less mercury-intensive than whole ore amalgamation. Therefore, it requires less mercury for the same amount of gold produced, and will have a smaller Hg:Au ratio. The ratio for mechanized production will differ from that of manual production. The ratio for one mechanized set up may well differ from that of another mechanized set up. So when we speak of the Hg:Au ratio, it is important to remember that there are many Hg:Au ratios, one for each processing method.

The Hg:Au ratio can vary over time even for a single processing method. Depending on the skill level of the miner, the time and care taken in mercury recovery, *etc*., one processing unit can yield multiple Hg:Au ratios. For this reason, measurements must be repeated (at least three times) and averaged to determine the Hg:Au ratio for a single processing method.

Since ASGM processing methods often vary between regions, or even between sites within the same region, the Hg:Au ratio can vary greatly. This means that while the Baseline Team is deducing reasonable estimates of how much gold is produced in a region and how much mercury is needed to produce each gram of this gold, they are *also* taking note of the variation in production methods within the region, as this will affect which Hg:Au ratios are applied and to what proportions of the regional gold production.

Example

At Processing Site A, processors are carrying out whole-ore amalgamation. On average, they are using 90 g of mercury to produce 30 g of 24K gold. At neighbouring Site B, the processors are conducting concentrate amalgamation. Field Researchers here are finding that it takes an average of 20 g mercury to produce 15 g of 24K gold. What is the Hg:Au ratio for each processing method?

Hg:Au Site A (whole ore amalgamation) = 90 g Hg / 30 g Au = **3:1**
Hg:Au Site B (concentrate amalgamation) = 20 g Hg / 15 g Au = **1.3:1**

7.4.5. Mercury Recovery with Retorts

But this is not the full story. Sometimes, mercury is recovered during processing. This recovered mercury is reused and therefore is not lost to the environment. Recovered mercury must therefore be considered when calculating the Hg:Au ratio. One way to recover mercury is to use a retort. When vaporizing amalgam in the open air, 100% of the mercury is lost. When vaporizing amalgam in a retort, a large portion of the mercury is recovered for re-use.

Example

Let us go back to our example. At Site A the processors are burning their amalgam in open air. Here, 10 g of Au are yielded, and no Hg is recovered (it is all lost into the air). At Site B, the Field Researchers find that processors are now burning their amalgam in a retort, yielding 10 g of Au and recovering 16 g of Hg from the amalgam burning phase.

The calculation for Hg:Au looks like this:
Hg:Au = (Hg added – Hg recovered) / (Au produced)

Hg:Au for Site A (whole-ore amalgamation, amalgam burn in open air)
= (90 g – 0 g) / 10 g = **9:1**

Hg:Au for Site B = (concentrate amalgamation, amalgam burn in retort)
= (20 g – 16 g) / 10 g = **0.4:1**

At Site A, without a retort, all mercury added during processing was lost. At Site B, the use of a retort cut the mercury emission by 80%.

7.4.6. Applying the Hg:Au Ratio

Once Hg:Au ratios are established, they are very useful. They can be applied to a known quantity of gold production to form an estimate of how much mercury was used in producing that gold. As we saw with the concentrate versus whole-ore amalgamation example, the Hg:Au ratio changes depending on the ore processing method used. It is important to note that a given Hg:Au ratio is unique to the specific set of criteria used in its calculation: processing method, ore composition, and ore grade. This means that the Hg:Au ratio of one region should not be applied to another region unless the two regions can be shown to have similar characteristics. Since these criteria may also vary within a given region or processing method, again it is important that measurements be taken on several similar processing units and averaged to determine the characteristic Hg:Au ratio for a processing method.

Continuing the previous example, Site A was found to produce 22 kg of 24-K gold per year. Site B was found to produce 35 kg/y. Only one type of processing is used on each site. How much mercury is used at each site, annually?

To calculate the mercury used annually at a site, we multiply the Hg:Au ratio specific to the site by the annual gold production on the site. Note that only one Hg:Au ratio and one gold production statistic are required for each site because only one processing method is used on each site. If more than one processing type as found on a site, we would need to know the Hg:Au ratio and annual gold production for each processing type. You would calculate the mercury use for each processing type and then add all mercury use values together.

Mercury used = (Gold produced) x (Hg:Au ratio)
i.e., **[gold produced (kg)] x [kg mercury used to produce 1 kg of gold]**

Hg used at Site A = (22 kg/y) x (9 kg Hg / 1 kg Au) = **198 kg/y Hg used**
Hg:Au for Site B = (35 kg/y) x (0.4 kg Hg / 1 kg Au) = **14 kg/y Hg used**

These are the amounts of mercury lost to the environment annually for each site. Note that concentration amalgamation and burning in a retort uses far less mercury than whole ore and burning in open air.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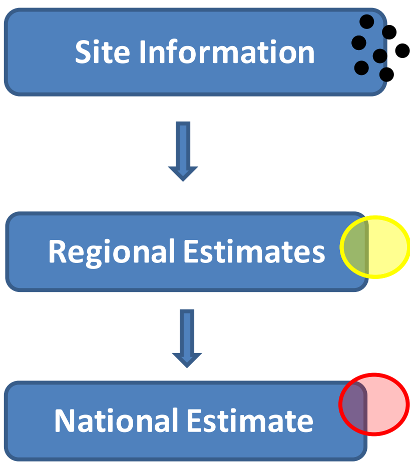


Site Information
Regional Estimates
National Estimate

8. Producing National Mercury Use Estimates from the Data

This section describes how to produce site-based information and averages of common variables relating to mercury use, gold production, and workforce from your data and how to upscale this information to regional- and national-scale baseline estimates.

8.1. Estimating Annual Mercury Use on a Site and Useful Site-based Variables

The data collected on an ASGM site are used to calculate the average of various key variables related to extraction, processing, transport, and earnings. Examples of key variables from extraction sites are number of miners per extraction unit, ore production per miner, and ore production per extraction unit. Examples of key variables from processing sites are daily ore throughput, daily gold production, mercury use, and number of processors per processing unit. The values of the variables are derived using several sources (several interviews, on-site observations and measurements) and cross-checked to lend confidence.

Example

A Baseline Team arrives on an extraction site and finds both mine shafts and small open pits. The team counts:

- An average of 10 miners per mining shaft
- 6 mining shafts on the site
- An average of 4 miners per pit
- 20 pits on the site

How will the team find the total miner workforce on this site?

Total miner workforce on site:
(6 shafts x 10 miners/shaft) + (20 pits x 4 miners per pit)
= 140 miners

Annex A4 provides equations that can be used to determine key site-specific variables.

8.2. Estimating Mercury Use in a Region: Extrapolation

Rregional estimates can be found in one of two ways, depending on whether every site in the region can be visited.

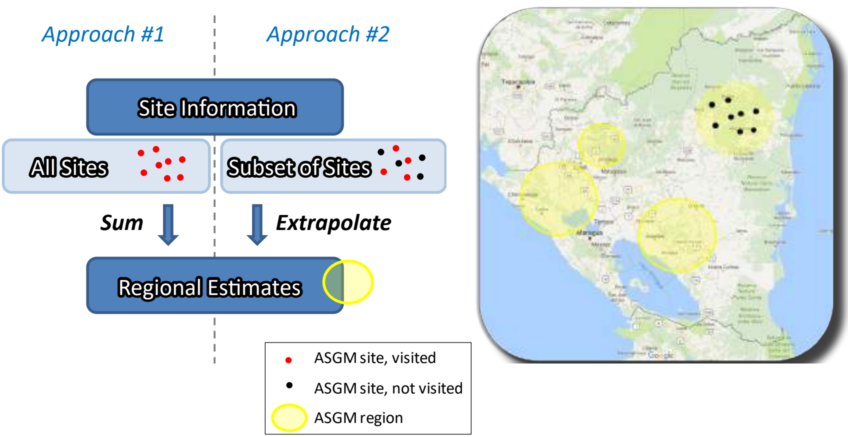
8.2.1. Approach 1: Visit All Sites in the Region

If data have been collected for all sites in the region, the regional baseline estimates of gold production, mercury use, and workforce are found by summing the estimates of all sites within the region. This is possible in a country with a relatively small and simple ASGM sector.

8.2.2. Approach 2: Visit a Subset of Sites in the Region

In a country with a large and/or complex ASGM sector, it is usually impossible to visit all of the sites in each region in the time allotted for the project. In this case, field data is collected at a subset of sites and a regional estimate is found by extrapolating the site subset data to a regional scale. To extrapolate data from a subset of sites to the region, there must be at least one known piece of information about the region that is ASGM-related. The averages of variables calculated on the sites are extraoplated to regional data based on this piece of information.

Many different pieces of regional information can be used for extrapolation, as long as the information is (a) regional; (b) relevant to the local data collected; and (c) reliable. For example, if you visited a subset of sites and found the average number of miners per pit and the average annual gold production per pit, two relevant pieces of regional data might be: the number of pits in the region and the number of miners in the region. See *Chapter 2, § 7.1.2* for more information.



Example

On page 79, we calculated the total miner workforce on a fictional extraction site to be 140 miners. There are 3 other sites in the region. How will the team estimate the regional miner workforce from this information?

Scenario 1 – Collect data from all sites

The Baseline Team is able to visit all four sites. They find miner workforces of 80, 65, and 210. What is the regional miner workforce?

Regional miner workforce = Sum of all sites

= 140 + 80 + 65 + 210

= 495 miners in the region

Scenario 2 – Collect data at some sites and extrapolate to the region using a piece of information about the region

The Baseline Team only has the time to conduct surveys and measurements at one more site. They see similar mining group structure here: there is an average of 10 miners per shaft and 4 miners per pit.

A piece of regional information is needed to extrapolate to a regional estimate. The Baseline Lead finds a register of the number of shafts and pits in the region (16 shafts and 80 pits). He cross-checks this number by hiring a local miner to drive with him from site to site counting the number of pits and shafts at each site (20 shafts and 84 pits). Since there is likely error in both figures, he averages these numbers to get 18 shafts and 84 pits.

Regional miner workforce estimate = [(avg number of miners per shaft) x (number of shafts in the region)] + [(avg number of miners per pit x number of pits in the region)]

= [10 x 18] + [4 x 82]

= 508 miners in the region

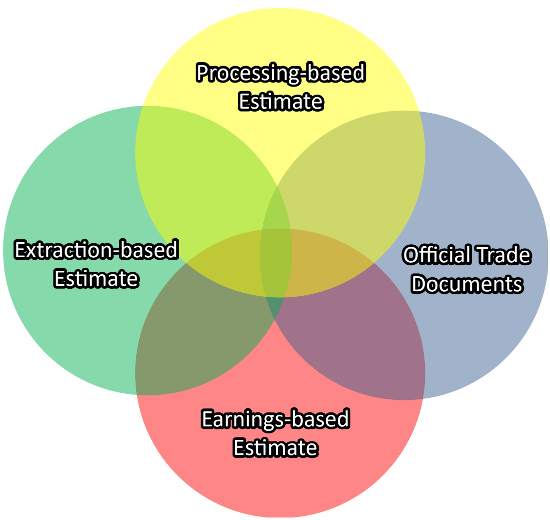
Chapter 2, Step 7 (Data Analysis Phase 2: Calculating Regional Estimates) presents some examples of regional extrapolation.

8.3. Cross-checking and Convergence (Triangulation) of Regional Estimates

Finding a good robust baseline estimate requires triangulation. Triangulation is the technique of comparing estimates from independent sources as a way of cross-checking the accuracy and validity of each of the several sources. Triangulation can be done on any type of estimate. For example, it can be done on gold production estimates before applying the Hg:Au ratio to get the mercury use estimate. It can be done on workforce estimates or ore production estimates. It should also be done on raw data as it is collected at ASGM sites *(see p. 60)*. Regardless of the variable being triangulated, the goal is to compile as many estimates of a variable from as many different sources as possible.

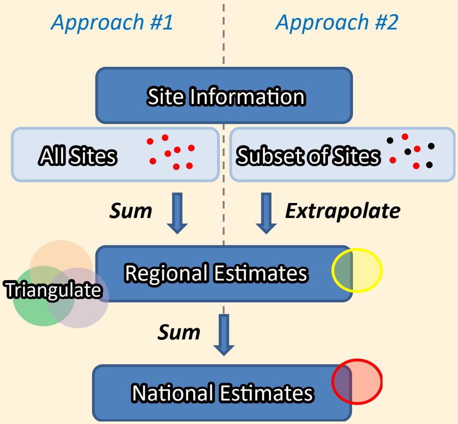
Following the step-by-step instructions given in Chapter 2 should yield four or five different independent sources for various regional estimates. These sources include official trade data; literature; gold traders; communities; mining and processing sites; ore transport; and earnings data.

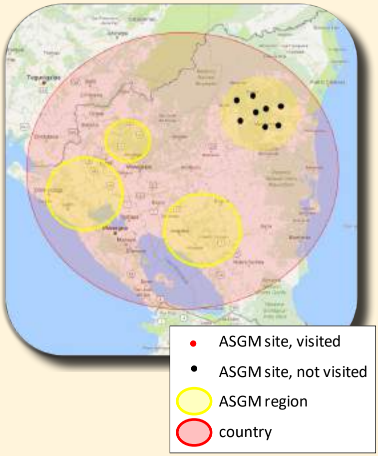
Compiling regional estimates from several of these different sources, the researcher is provided with a range of values. The narrower this range, the higher the likelihood that the estimate is accurate and the higher the confidence in the estimate.



8.4. Producing National Estimates

National baseline estimates are determined by summing the baseline estimates of all regions within the country for each of ASGM workforce, gold production, and mercury use.





Example

On page 81, we calculated the total miner workforce on a fictional region to be 508 miners by extrapolating from site information to the regional level. However, there are two other mining regions in the country. Using the same methods, the Baseline Team finds regional miner workforce estimates for each additional region. They are 235 for Region 2 and 387 for Region 3. How will the team find an estimate of the total miner workforce in the country?

National miner workforce estimate = sum of all regional estimates
= 508 + 235 + 387
= 1130 miners in the country


MARUKO

CHAPTER 2

ASGM BASELINE INSTRUCTIONS

A STEP-BY-STEP GUIDE

This chapter is a step-by-step guide designed to lead the Baseline Team to conduct the scoping, fieldwork, and data analysis necessary to form a national ASGM sector overview and baseline estimates of ASGM workforce, gold production, and mercury use.

1 Hire and train Baseline Team.

2 Conduct national ASGM sector scoping and regional visits.

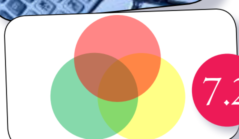
3 Make a country-specific research plan, select study sites.

4 Collect data in the field.

5 Record and analyse data and refine field methods.

6 Produce local information and averages of key variables from data.

7.1 Extrapolate local information to regional estimates.



7.2 Cross check regional estimates using several approaches, sources and reviewers.

8 Sum regional estimates to produce the national estimate.

Timeline of Tasks - Checklist

The following is a checklist of tasks that will lead to completion of baseline estimates of ASGM mercury use, gold production, and workforce and an overview of ASGM practices that are ready for the Nation Action Plan (NAP).

☐ Step 0. Familiarize with the material in Chapters 1 and 2 of this guidebook.

☐ Step 1.1. Hire a baseline team as per the criteria.

☐ Step 1.2. Train the baseline team using the training tools in the toolkit. The training should include instruction in the classroom and field. Training must be conducted by an ASGM expert.

☐ Step 1.3. Train key stakeholders. It is best if the stakeholders and baseline team are trained together for cost/time efficiency, shared dialogue, and mutual comprehension that saves time later. Field training days are not necessary for stakeholders.

☐ Step 2. Conduct ASGM sector scoping to find pre-existing information on the sector and provide a foundation for the baseline research plan. Include desk study and stakeholder interviews. *Optional tools: Sector scoping data template and report template (ASGM_scoping.xlsx & ASGM_scopingreport.docx).*

☐ Step 3. Design a baseline research plan for each major ASGM region. Involve baseline-trained stakeholders in planning; they know the baselining process and can lend valuable knowledge on the sector. If possible, have an ASGM expert review the plan.

☐ Step 4. Collect field data. *Tools: Field Forms (ASGM_forms.xlsx).*

☐ Step 5. Enter data into the database daily to calculate site-level estimates and key averages, cross-check results from different sources, and identify data gaps. If there are data gaps, adapt field approaches to address them. *Tools: Field Forms & ASGM Site Workbook (ASGM_site.xlsx).*

☐ Step 6. Produce a summary of site-level key variable averages and site-level baseline estimates. *Tools: ASGM Site Workbook (ASGM_site.xlsx).*

** Conduct steps 4 – 6 for each ASGM site in the region **

☐ Step 7.1. After the first round of data collection in a region, calculate a regional baseline estimate by extrapolating to the regional level. Extrapolate in as many ways as possible to support triangulation. *Tool: ASGM Region Workbook (ASGM_region.xlsx).*

☐ Step 7.2. Cross-check by comparing (triangulating) the results of multiple information sources and extrapolation approaches. Identify outliers (estimates that are far different than others) and discern whether they are a result of errors, a phenomenon that must be further explored in the field, or real. Also identify outstanding knowledge/data gaps and low confidence estimates.

☐ Step 7.3. Revise approaches as necessary and conduct a second field campaign directed at outliers, data gaps, and locations with low-confidence. Continue to analyse data daily, adapt methods, and modify study sites as necessary.

** Repeat steps 4 – 7 until high-confidence regional estimates are achieved and all vital knowledge/data gaps are filled **

☐ Step 8. Calculate the national baseline estimates by summing all regional estimates. *Tool: ASGM National Workbook (ASGM_country.xlsx).*

☐ Step 9. If possible, send the final baseline estimates for review by international experts and stakeholders.

☐ Step 10. Produce the final ASGM Baseline Report for inclusion in the National Action Plan.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Step 0 – Familiarize with Background Information, Baseline Process, and Tools

The Baseline Estimates Team (Lead and Field Researchers) may review Chapter 1 to familiarize with the baseline process, general concepts and terminology, sources of information, approaches, techniques, and supporting tools. The team should also familiarize with the instruction guide in this chapter before undertaking baseline activities.

Step 1 – Hire and Train the Baseline Team

This section will guide you to understand:

- The structure of the Baseline Team;
- professional traits required for each member role;
- the steps involved in training the field team and stakeholders and who should attend the training sessions.

Background reading:

- ASGM baseline training materials (Annex B)

1.1. Hire the Baseline Team

The ASGM **Baseline Team** is made up of the **Baseline Lead** ("**Lead**”) and a group of **Field Researchers** ("**Researchers**").

The **Basline Lead** is responsible for the ASGM baseline project. The Lead conducts scoping on the national ASGM sector and develops a research plan that (1) is appropriate for the country and (2) will lead to robust regional and national baseline estimates. He or she is responsible for ensuring Field Researchers are trained in the aims and methodology of ASGM baseline research. Lastly, the Lead will compile and analyse all baseline data in collaboration with the Field Researchers to produce national baseline estimates and recommendations for the NAP.

The Lead is an expert who has a thorough understanding of ASGM, geology, the scientific method, and Minamata NAP requirements. He or she must have strong skills in data acquisition, management, analysis, and reporting. He or she must also be a strong communicator to impart effective training to the Field Researchers.

The **Field Researchers** assist the Lead in collecting data at stakeholder locations and ASGM sites through interviews, surveys, and physical measurements. While the Lead participates in the field, the Researchers provide additional eyes on the ground, observing local ASGM characteristics and suggesting modifications to approaches. The number of field researchers depends on the size and complexity of the ASGM sector, the timelines for data acquisition, and financial resources available.

A Researcher must be quick thinking, open-minded, and a good problem solver. Ideally, they should have experience in the field, skills in data acquisition and management, and basic knowledge of the scientific method. He or she must understand the ASGM sector and its various components (mining, processing, and economics) or have the ability to learn these points through the training modules. They must be given plenty of practice in baseline problem-solving through case study and field learning excursions and should have access to the baseline support tools found in this guide book. Perhaps most importantly, a researcher must be friendly, communicative, culturally understanding and sensitive, aware that every case is different, and be comfortable with the fact that adapting quickly is common and essential. It is best that at least one team member has a social background to supplement the technical skillset of the Lead.

It is recommended that the team include at least one ASG Miner with good communication skills. Having a ASG miner on the team will improve access to information from sites and will also help with 'reality checks' and verification of data. One miner may hold a permanent role, or a new miner may join the team for each ASGM mining region. The latter option is beneficial as on-the-ground realities may change significantly between regions in terms of culture, technology, willingness to cooperate, and more.

Ultimately, the **Baseline Team** is responsible for the quality of the ASGM Estimates. Researchers need to comprehend and collect thoughtful, relevant and high-quality data that involves significant financial, time, and opportunity costs. Advice and feedback from external reviewers, experts, or technical tools such as guides and instructions are helpful aides, but the achievement of good results falls on the individuals carrying out data collection. For this reason, one of the biggest determinants of success is the selection of a capable Baseline Team.

1.2. Train the Baseline Team

Provide training for the Baseline Team and key stakeholders using the materials provided in Annex B. The training must be conducted by an ASGM baseline expert; either the Baseline Lead or a local or international expert.

"To successfully complete estimates of ASGM mercury use, a crucial first step is to build a baseline team that understands the technical, social, economic, political, and ore processing context" [1]

1.2.1. Developing Training Materials

The training materials provided in Annex B include a workshop curriculum, presentation slides, and a practice hand-out. Annex A1 contains the field forms. Tailor these to the context of the country and, where possible, translate them into local languages.

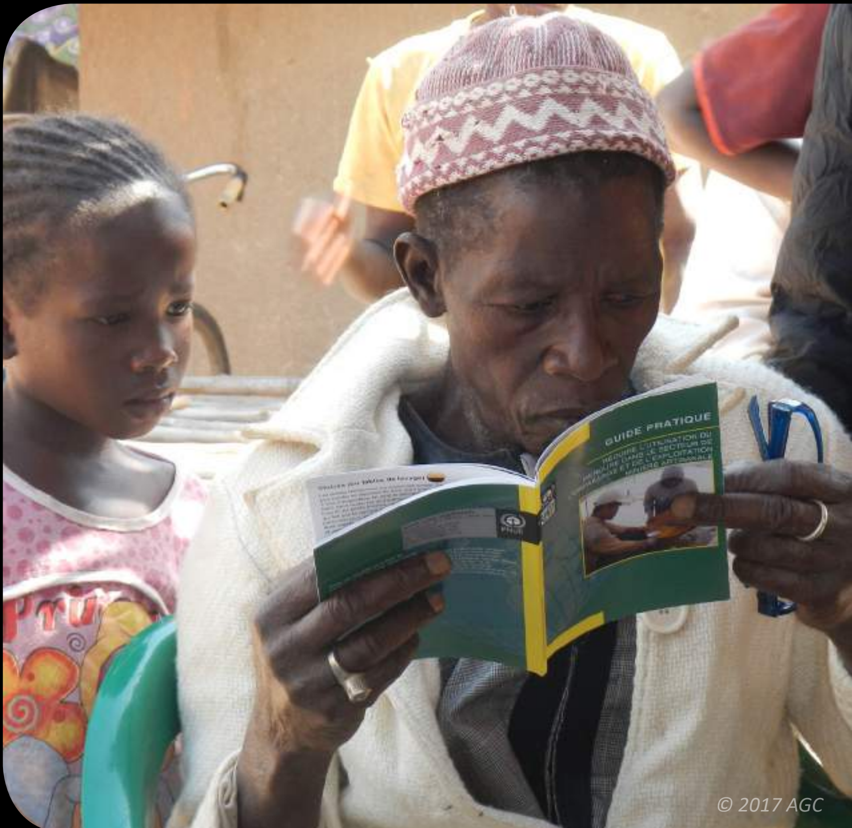
1.2.3. Delivery of Training

A training duration of four to five days works well. The first one or two days can spent in the classroom. On the first day is (1) an introduction to the ASGM sector; (2) an introduction to the ASGM baseline process; and (3) techniques, methods, and tools available for ASGM mercury baseline research. On the second day, a case study is presented and practice calculations and exercises are carried out. Two to three days are then spent in the field for practical training in mercury measurement techniques and other data collection. The final day is spent back in the classroom for a review of the data collected, questions, and lessons learned, and a discussion of the constraints and efforts required for a sampling program in the specific country.

1.3. Train Key Stakeholders

Conduct the same training for key ASGM stakeholders. It is best if the stakeholders and baseline team are trained together, for the sake of efficiency, shared dialogue, and mutual comprehension which saves time later. It is beneficial for stakeholders to comprehend the ASGM baseline approach because they will be informing the baseline research plan and cross-checking results. *Field training days are not necessary for stakeholders.*

[1] UN Environment Guidance Document: Developing a National Action Plan to Reduce, and Where Feasible, Eliminate Mercury Use in Artisanal and Small Scale Gold Mining.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Step 2 – National-level ASGM Sector Scoping

To determine the best way to conduct ASGM baselines, a good understanding of the sector is required. Here, you will conduct sector scoping research to understand at a national and regional level: (1) distribution of ASGM sites; (2) governance of the sector and sites; (3) mineralogy; (4) ASGM gold and mercury trade; (5) technology used; (6) socioeconomics, health, and environment; (7) knowledge gaps; and (8) priority areas for NAP strategies.

This section will guide you to:

- Find and assess existing information from literature, maps, stakeholders, mining hubs, and sites to gain an overview of the ASGM sector;
- compile the necessary information to inform a baseline research plan.

Background reading:

- Chapter 1, 2.3. What Information Needs to be Collected? (p. 38)
- Chapter 1, 3. National-level ASGM Sector Scoping (p. 46)

Supporting tools used in this step:

- Data organisation tool (Annex A2):
  ASGM_scoping.xlsx
  *(Sheets: '**Literature**' & '**Stakeholders**')*
- Report templates (Annex A2):
  ASGM_scopingreport.docx

Here is what must be done to complete the scoping phase. Each of these components is described in the following sections.

- Desk research / literature review
- Interviews with existing contacts and stakeholders
- Visits to the capital and major regional mining hubs
- Visits to a small number of ASGM sites

2.1. Desk Research

The ASGM sector scoping phase begins with desk research. While reading all relevant ASGM-related documents available, the Baseline Lead asks:

a) Is information on the ASGM sector available?
b) If yes, what type of information is available and what is the quality of it?

Search for literature, registers, maps, and aerial images using libraries, stakeholder archives, databases, knowledge hubs, and internet search engines. Also include a legal and regulatory review of the laws and regulations surrounding the ASGM sector. Literature may not always exist in a frontier type situation; however, a thorough attempt should be made to find all available information.

Sources of information:
Use **Table 1-2** *(p. 47)* and **Table 1-5** *(p. 51)* of *Chapter 1, Section 3.1. Sources of Information* as a starting point. Other sources, if available, should be included. Consider what information will be useful in producing baseline estimates, particularly regional information that could be used to extrapolate site information to the regional scale. The amount of new data that can be collected and the extent to which literature-based data must be relied on will be governed by the quality of the published data and the time and resources allotted to the baseline estimates.

Supporting Tool (optional):

> Open **ASGM_scoping.xlsx** and select the '**literature**' sheet. Enter the reference information for each document in the table with information and/or knowledge gaps it highlights.

ASGM National Level Sector Scoping

Literature Review Record and Notes

author	year	title	source	theme	notes

2.2. Interview ASGM Contacts and Stakeholders

Identify and solicit known ASGM stakeholders for interviews. The goal of these interviews is to gather as much information as possible about the major ASGM mining regions, governance of the sector, extraction and processing methods, and, for each work flow, the ore production, throughput, grade, purity, and mercury used.

Stakeholders may be found at the national, regional, municipal, and site level (*i.e.*, in the country's capital, regional capitals, mining hubs, communities, and ASGM sites). Initial contacts may not be available in a frontier situation, but the goal is to gather as much information as possible and build your list of contacts as you go.

Sources of information:
Refer to **Table 1-3** of *Chapter 1, Section 3.1. Sources of Information (p. 48)* for a list of potential stakeholders and key information that each might contribute. This table is a useful starting point. The information held by each stakeholder varies. It is up to you to ask the most regionally relevant questions.

Supporting Tool (optional):

Open **ASGM_scoping.xlsx** and select the '**stakeholders**' sheet. When you identify a stakeholder, enter the name, agency, and contact information. After each interview, add notes about information provided and/or knowledge gaps highlighted.

ASGM National Level Sector Scoping

Stakeholder Contact Sheet and Notes

The Capital

stakeholder institution	location	contact person	phone	email	contacted? (Y/N)	notes

Mining Region 1: [Region Name]

stakeholder institution	location	contact person	phone	email	contacted? (Y/N)	notes

2.3. Visit the Country's Main Administrative centre, Regional Mining hubs, Communities, and ASGM Sites

The national capital and hubs of major mining regions must be visited to meet with contacts in person, collect information, gain insight into the distribution and characteristics of sites and extraction and mining methods, and establish an understanding of the on-the-ground realities of the sector.

Sources of information:
Refer to **Table 1-3** and **Table 1-4** of *Chapter 1, Section 3.1. Sources of Information (pp. 48-50)* for a list of stakeholders found at the capital, regional hubs, communities, and ASGM sites, and key information that each might contribute. This table is a useful starting point. The information held by each stakeholder varies. It is up to you to ask the most regionally/locally relevant questions.

Supporting Tool (optional):

> Open **ASGM_scoping.xlsx** and select the '**stakeholders**' sheet. When you identify a stakeholder, enter the name, agency, and contact information. After each interview, add notes about information provided and/or knowledge gaps highlighted.

ASGM National Level Sector Scoping Stakeholder Contact Sheet and Notes						
The Capital						
stakeholder institution	location	contact person	phone	email	contacted? (Y/N)	notes
Mining Region 1: [Region Name]						
stakeholder institution	location	contact person	phone	email	contacted? (Y/N)	notes

2.4. Compile Results in an ASGM Sector Scoping Report

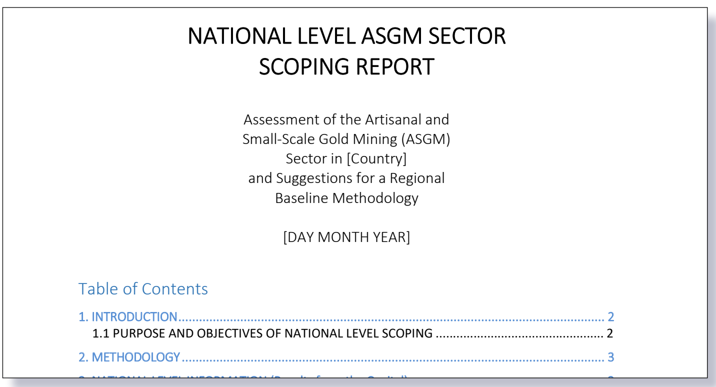
Document the exisitng information on the ASGM sector by compiling the results of the national-level sector scoping in a report.

- Summarize the spatial distribution, organization, and practices characterising each major mining region in the country.
- Include a map of the major mining regions and the general distribution of ASGM sites within them.
- Highlight pre-existing information that will be useful to calculate baseline estimates for each region.
- Identify knowledge gaps that must be filled by further investigation in the field.
- Based on the key existing information and knowledge gaps, recommend baseline estimate approaches and methods for collecting field data.

Note: The report is not a formal requirement of the Minamata Convention. It will however, be instrumental in guiding the development of your field research plan. The content will also be used in the ASGM sector overview, a requirement of the NAP.

Supporting Tool (optional):

Open **ASGM_scopingreport.docx**. This document will guide you in documenting the existing ASGM information in an organized way.



NATIONAL LEVEL ASGM SECTOR
SCOPING REPORT

Assessment of the Artisanal and
Small-Scale Gold Mining (ASGM)
Sector in [Country]
and Suggestions for a Regional
Baseline Methodology

[DAY MONTH YEAR]

Table of Contents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Step 3 – Design a Research Plan and Select Sites

Now that a base understanding of the country's ASGM sector has been developed, it is time to design approaches for producing regional ASGM baseline estimates.

This section will guide you to:

Produce a research plan for the country that:

- Proposes baseline approaches for each major mining region;
- incorporates contextual knowledge from the sector scoping report;
- identifies useful pre-existing information and info that is needed;
- outlines how the old and new information will be coupled to produce regional and national estimates;
- proposes how the new information will be collected; and
- identifies a subset of ASGM sites for data collection that are representative of regional practices and production.

Background reading:

- Chapter 1, Section 4: Research Plan and Study Sites (p. 52)

When planning ASGM baseline research, aim to use as much existing information as possible, identify data gaps in the existing information, and then fill these data gaps with new field data to find regional estimates. The first step in making a research plan is therefore to consult the ASGM sector overview compiled in the **National Sector Scoping Report** in Step 2. This overview should contain the existing data for each region (which helps to identify data gaps); the mining and processing techniques used in each region (which helps to identify suitable data collection approaches); the on-the-ground realities at ASGM sites (which helps to address accessibility and logistics); and the distribution of ASGM activity (which helps to select target sites).

There are five steps to carry out when developing a national research plan:

3.1. Compile knowledge
3.2. Select study sites
3.3. Select baseline estimate approaches, identify data gaps
3.4. Outline a data collection strategy to fill data gaps
3.5. Allocate resources (make do with what you have)

3.1. Compile Knowledge

All existing information on the country's mining regions is now in the Sector Scoping Report. Baseline estimating approaches will be based on this available data.

Existing knowledge is extremely useful, but can only take the baseline estimate so far. In most countries, gold production from ASGM is under-reported because it is produced in the informal economy, which does not keep records, and also due to smuggling and tax avoidance. But, even countries with accurate production reporting will have little reliable data on the Hg:Au ratio. ASGM workforce is often unknown or grossly underestimated as, due to the often-informal nature of the sector, a miner licence system or other official workforce record is not always in place. The only way to determine the validity of reported information and to find missing data is to make observations and take physical measurements on site.

3.2. Select Study Sites

Financial resources and time are a vital determinant of how extensive collection of field data and refinement of the research plan can be. With unlimited funding, personnel, and time, interviews and measurements could be conducted at every ASGM site in the country. However, more realistically, there will be a timeline of months and an Baseline Team of a limited size. In this case, it is often impossible to characterize all ASGM sites within the given time and resources. Information must therefore be collected strategically from a well-defined subset of target sites that are representative of a region.

It is crucial that the subset of target sites be as representative of the region as possible. Site selection must consider the extent and relative distribution of ASGM activities, the accessibility of ASGM sites, the size of the field team, the timeline, and financial resources. A general understanding of the ASGM sector, regions, practices, existing information, and scope of the project are therefore essential in defining this subset. The goal is to ensure that the baseline estimates resulting from the field work acount for the variation in the region.

Remember, to accomplish this, the Baseline Team must ask:

Where is the concentration of ASGM activity?
In what general areas are the greatest mercury use, gold production, and miner populations found? Priority sites will be those with greatest ASGM productivity and/or livelihood earnings, and/or mercury pollution.

Where are the different extraction and processing technologies located?
ASGM extraction and processing techniques often vary between and even within regions. The amount of mercury used to produce a gram of gold (the Hg:Au ratio) can vary greatly from one site to another and even within a site, depending on the type of ore being extracted and the processing techniques applied. This means that as the team selects target sites and approaches, they must keep in mind the variation in technology, between and within regions, that will alter the Hg:Au ratio.

Which sites have extraction and processing practices that reflect the full range of ASGM practices found in the region? These will be priority sites because they capture the full range of technologies in one site visit, making data collection most efficient and cutting down on travel time and cost.

What and where are the knowledge gaps? Prioritise them.
In what regions are new field data required to fill knowledge gaps? These will also be priority sites because all regions must be characterised with certainty. Remember, the way you estimate mercury use for a region depends on whether you visit all sites, or a subset of sites.

Regional baseline estimates ultimately come from combining all site-based information. The method of combining site-based information will differ depending on whether all sites in the region were visited, or a subset of sites.

Remember, the way you estimate mercury use for a region depends on whether you visit all sites, or a subset of sites.

Approach 1 – All Sites

If the region is small, visit ALL sites in the region and find an estimate of mercury use for each by:

- visiting all sites in the region;
- collecting site-specific data; and
- determining site-specific estimates for each of the sites using one or many of the estimation approaches (extraction-based, processing-based, earnings-based or other) presented in *Chapter 1, Section 7.*

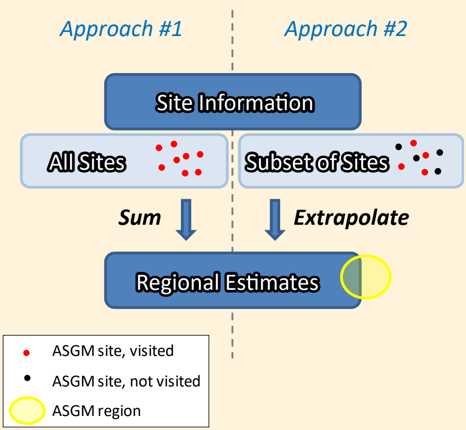
To produce regional estimates, all site-specific estimates are summed.

Approach 2 – A Subset of Sites

If the region is too large to visit all sites, visit a representative subset of sites in the region. Information will be needed for the sites that were missed. In this case,

- visit each site in the subset;
- collect site-specific data; and
- determine key variables for these select sites.

To produce regional estimates, these key variables are coupled with known information about the region (*e.g.*, regional miner population, number of processing systems in the region, gold production in the region, the number and relative size of all sites in the region) to extrapolate from site-based or extraction/processing unit-based estimates to regional estimates.



3.3. Select Approaches

Select approaches that use as much existing information as possible. Your may select from the following list (described in *Chapter 1, Section 7*), or create others. Identify which data are needed to complete the selected approaches.

1. **Official Trade Data – ASGM Mercury:** Mercury import data from official government documents.

   Where to find the data: *ASGM Sector Scoping Report*
   Information: *Chapter 1, Sections 2.3.2., 3.1.2, 7.1.*

2. **Official Trade Data – ASGM Gold:** Gold production from official government documents. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/ method.

   Where to find the data: *ASGM Sector Scoping Report*
   Information: *Chapter 1, Sections 2.3.2., 3.1.2., 7.4.1, 7.4.2.*

3. **Stakeholder Interviews – ASGM Gold:** Gold production from interviews with various stakeholders (*e.g.*, government mining office, LSM, local administrator, community leader, mining coordinator). Apply Hg:Au ratios from site measurements.

   Where to find the data: *Community Interview Data, Hg:Au Ratio Data*
   Information: *Chapter 1, Sections 2.3.2., 3.1.2., 5.2.1., 6.1 – 6.4., 7.4.2.*

4. **Gold Trader Interviews – ASGM Mercury:** Interview local and regional gold traders located that sell mercury. The amount of mercury sold weekly/ monthly/annually by these gold traders provides a rough estimate of the mercury used by ASGM in that region. If not all gold traders in the region can be visited, survey a sample of gold traders and extrapolate according to the number of gold traders in the region.

   Where to find the data: *Gold Trader Interview Data*
   Information: *Chapter 1, Sections 1.9.2., 2.3.2., 5.2.1., 6.3., 7.2.*

5. **Gold Trader Interviews – ASGM Gold:** Gold production based on the gold purchased annually by regional and on-site gold traders. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/method.

   Where to find the data: *Gold Trader Interview Data, Hg:Au Ratio Data*
   Information: *Chapter 1, Sections 1.9.2., 2.3.2., 5.2.1., 6.3., 7.4.1., 7.4.2.*

6. **Extraction Data – ASGM Gold:** Gold production based on interviews at extraction units. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/method.

   Where to find the data: *ASGM Site Interview, Site Observations, Hg:Au Data*
   Information: *Chapter 1, Sections 1.4., 5.2.1 – 5.2.3., 6.5., 7.4.1., 7.4.2.*

7. **Ore Transport Data – ASGM Gold:** Ore production based on interviews with ore transport workers or observation of ore transport. Gold production through combining ore production with typical ore grade, gold purity, number and schedule of transport vehicles/workers. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/method.

   Where to find the data: *ASGM Site Interview, ASGM Site Observations, Hg:Au Ratio Data*
   Information: *Chapter 1, Sections 1.5., 5.2.1 – 5.2.3., 6.5., 7.4.1., 7.4.2.*

8. **Processing Data – ASGM Mercury:** Mercury use based on interviews at ore processing units. Ask how much mercury is purchased weekly/ monthly/ annually to replace the mercury that is lost. This is a rough estimate but is suitable as a cross check of other approaches. One benefit: it considers the amount of "dirty" mercury that is discarded.

   Where to find the data: *ASGM Site Interview Data*
   Information: *Chapter 1, Sections 1.6., 5.2.1 – 5.2.3., 6.5., 7.3.*

9. **Processing Data – ASGM Gold:** Gold production based on interviews at processing units. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/method.

   Where to find the data: *ASGM Site Interview, ASGM Site Observations Data, Hg:Au Ratio Data*
   Information: *Chapter 1, Sections 1.6., 5.2.1 – 5.2.3., 6.5., 7.4.1., 7.4.2.*

10. **Earnings Data – ASGM Gold:** Gold production based on interviews with stakeholders (miners, bosses, coordinators, concession owners, cooperative leader and members, community leader, gold traders, *etc*.) about revenue distribution between stakeholders. Apply Hg:Au ratios from site measurements, applying different ratios to the proportion of gold allocated to each processing practice/method.

    Where to find the data: *Community, Gold trader, and ASGM Site Interview Data, Hg:Au Ratio Data.*
    Information: *Chapter 1, Sections 1.8., 5.2.1., 6.1. – 6.5., 7.4.2.*

3.4. Outline a Data Collection Strategy

Develop a strategy for collecting data that is suited to the region and approach(es). For example, in a region where only sluices are used, you could count total sluices and use a processing-based estimate approach. You would use ore grade, gold purity, typical number of operators per sluice (workforce); average daily throughput per sluice (gold production), and Hg:Au ratio for a sluice (mercury use). At typical hard rock sites, one might use a combination of extraction and processing-based approaches. Plan for as many approaches as possible, to ensure high confidence in your final estimates through cross-check.

Important Consideration

The Lead must ensure that the data sought and proposed data collection strategies offer the most robust baseline estimates while considering the available resources and on-the-ground realities of the regions.

3.5. Allocate Resources

After site selection, you know how many ASGM sites you need to visit. In an ideal world, funding and resources would adjust to meet the task at hand. In reality, the task must be adjusted to fit the resources. The time that can be devoted to each site will thus be a function of how much time, money, and staff are available for the baseline research. In terms of resources, it would typically take a team of two trained researchers (or a researcher and an assistant) from one to three weeks per region to obtain reasonably accurate and useful data on production and mercury use. One week is extremely rushed and would yield rough estimates only. Two weeks is reasonable. Three weeks should produce robust data. Time to write up and present results are additional to this interval.

For example, a country with 3 to 4 regions should require 6 to 12 weeks of field time. A country with 7 regions should require 14 to 21 week of field time. For a country with a single very large region and a few very small regions, the large region could conceivably be done in two weeks, but given the importance of the site, a month-long mission would be more appropriate. The Lead would also need to decide whether to visit only the one site, or include one or two other sites for geographical balance.

Important Consideration

Oftentimes, unknown conditions can make complete site selection and method preparation difficult. To deploy resources most effectively, field visits are often required to develop a clearer understanding of the region.

3.6. External Review of the Plan

If possible, once a written plan of the proposed baseline research plan is completed, send the plan for review by external experts. These experts may be local or international agencies or stakeholders who were present at the training session and familiar with the sector and the baseline research process.

3.7. Continual Refinement of the Research Plan

Keep in mind that the research method developed at the desk is preliminary. The initial methodology will likely not be applicable to all sites visited. At some sites, new field practices may be discovered. At other sites, unforeseen field realities may be encountered that render planned methods unfeasible or invalid. So the sites and data collection methods may change after initial site visits, initial data collection, and as the team becomes familiar with the sector. Keep an eye on the site details (variation in units of measure and mining methods), assess this information quickly, and modify measurement approaches and interview questions as needed. Sometimes the situation will call for new approaches that are not included in this guidebook.

3.8. Summary

In summary, use the following "recipe" to form the baseline research plan for each region:

PLAN

1. A statement of the scope and context of the project.
2. A map of the major ASGM mining regions.
3. A summary of existing data available for the country and for each major ASGM mining region. Include data on ASGM gold production, mercury use, and workforce and known characteristics of the sector (location, access, technology, politics).
4. Approaches for estimating mercury use in each ASGM region. Identify multiple approaches, using *Chapter 1, Section 7*.
5. A list of data required for each approach and the calculations in which they are used. Identify which data are currently known and which are missing.
6. A description of how the missing data will be collected in the field;
7. A list of ASGM sites and stakeholder locations to visit for data collection. If it is not possible to visit every site in the region (most cases), this list is a subset of sites that represents the range of practices and productivity in the region. Using your judgement, aim to have the list represent a cross-section of types of sites that covers differences in practices and size (large to small).
8. A discussion of which approaches should be used for specific sites: "If this style of mining (hard rock, alluvial, whole ore, concentrate, *etc.*), we recommend this approach." This is where an experienced expert must review the existing information to determine the best methodology/ strategy.
9. Allocation of time and resources, including number of days, number of field researchers, and the budget allotted to each target site.
10. An outline of potential risks associated with the proposed research approach and how these can be minimized.
11. A package of data collection and analysis tools that includes printed paper field forms, data entry and analysis tools, and relevant equations and formulas selected from Annex A.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Step 4 – Collect Data in the Field

It is time to collect field data. In this section, a research sequence is recommended. The data gathered in this phase will lead to site-level information about ASGM operations and baseline estimates for individual sites.

This section will guide you to:

- Visit the correct locations in a region;
- conduct research in a logical order of locations and tasks;
- know who to contact and interview at each location.

Background reading:

- Chapter 1, Section 5: Collecting Data in the Field (p. 53)
- Chapter 1, Section 6: Where to Go, Who to See (p. 63)

Supporting tools used in this step:

- Data collection forms (***ASGM_forms.xlsx***, Annex A1):
  - **Community Interview**
  - **Gold Trader Interview**
  - **ASGM Site Observations**
  - **ASGM Site Interview: Extraction**
  - **ASGM Site Interview: Processing**
  - **ASGM Site Interview: Transport**
  - **Hg:Au Ratio**
  - **Others**, as determined by research plan
- Data synthesis and analysis tools (Annex A3):
  - **ASGM_site.xls**

4.1. Preparations

For data collection to be successful, the baseline research methodology for each region must be clear to the field researchers. The researchers must understand which data are required to produce regional estimates and how this data will be used in the regional methodology.

You may wish to or be required to write up a **travel plan** and file it with the national office by email. The travel plan includes a schedule for keeping in touch with the national office and the headquarters of your research group.

Make sure you have the **telephone numbers** for the national office and the headquarters of your research group. Record these in your notebook. Store them on your mobile phone and/or satellite phone.

Print off the number of **field forms you need and several extra**. Install spreadsheet software and download the **spreadsheet workbook files** (***ASGM_site.xlsx, ASGM_region.xlsx, and ASGM_country.xlsx, Annex A3***) on all field laptops. The forms can be opened in Microsoft Excel or Apache OpenOffice Calc, which is open source and free.

Prepare a **pre-departure checklist** of equipment and use it to organize your team before you leave for the field.

Access to Information

When requesting information from official sources, you may encounter an informal restriction on access. Before incurring any costs to access information, including contracting officials for services, make sure that you are not in contravention of any rules. It may be helpful to check with a higher authority about what the expectations are in advance.

4.2. Daily Diligence in the Field

At the end of each field day, or the following morning before departure to the field, the researchers should enter the data from their field forms into the ASGM Site Workbook (***"ASGM_site.xlsx", Annex A3***) and attempt to calculate key site-level variables and baseline estimates of workforce, gold production, and mercury-use. These daily calculations ensure that all data has been collected or show what information has been missed and how data collection can be adapted to yield better data. See *Section 6.1 (p. 134)* of this chapter to learn how to use the workbooks.

1. Ensure the key variables and baseline estimates make sense through a geological lens, income lens, and knowledge of the sector. Cross-check these values by multiple methods (*e.g.*, processing- vs. income-based approach vs. official records approach).
2. List all missing information for collection the following day.
3. Outline changes to data collection to yield better data tomorrow.

A Note on Data Quality

Ultimately, the **Field Researchers** are responsible for the quality of the ASGM baseline estimates. Researchers need to comprehend and collect thoughtful, relevant and high-quality data that involves significant financial, time, and opportunity costs. Advice and feedback from external reviewers, experts, or technical tools such as guides and data analysis workbooks are helpful aides, but the responsibility for good results falls on the team of researchers carrying out good data collection and educated critical thinking in data analysis.

4.3. Data Collection: Sequence of Locations and Tasks

The following chart (**Figure 2-1**) shows the locations that should be visited on a research mission in to an ASGM region. Circumstances may vary; A region may not have all these locations, your team may not be able to visit all locations, or you may choose to visit several examples of a location (*e.g.*, several gold traders or communities). Adapt the sequence as necessary.

The following sections break down what to do at each location. Remember, it is always better to collect too much information than to end up with too little!

To review the techniques and tools available for collecting field data and assessing its quality, see *Chapter 1, Section 5: Collecting Data in the Field (p. 53)*.

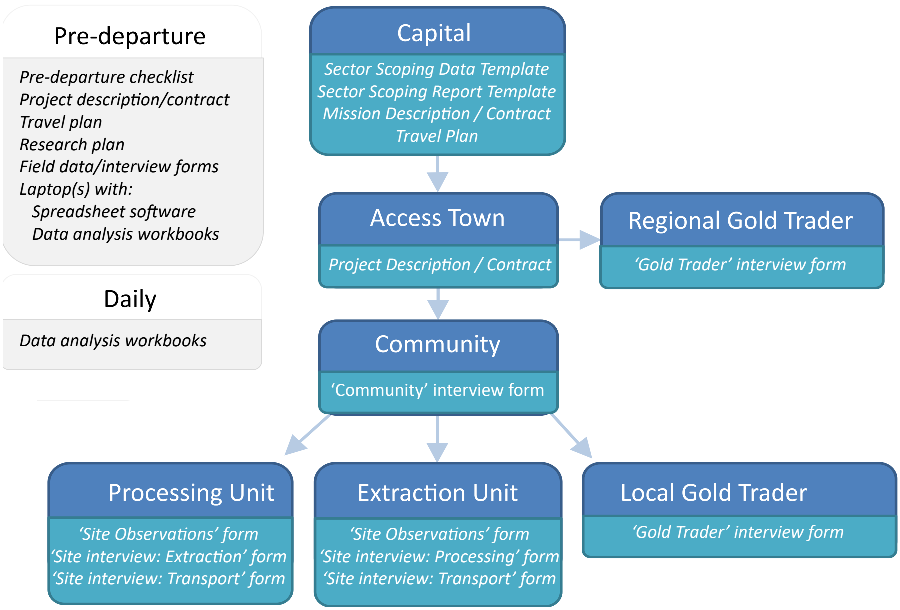


Figure 2-1. Suggested sequence of locations to visit during baseline research in an ASGM region and tools available for each location.

Accounting for Informal Mining and Mercury Use

All methods outlined in this guide are applicable to informal mining. In many countries, informal mining may constitute the majority of ASGM operations and therefore, these operations must always be accounted for. Enough information must be gathered about informal mining activities to be representative of their contribution. The line between legal and informal and illegal and extralegal is often unclear and so thoughtfulness and common sense should be exercised in engaging with both miners and legal authorities.

4.3.1. Research steps in the main administrative centre (national, regional, provincial capitals and internet)

** The research steps in the main administration centre will be largely, if not entirely, covered in the national sector scoping step.*

1. Visit the Ministry of Mines or other relevant authority. Explain the project and the purpose of your research mission. If a **project description** or **contract** is required, bring it to be signed by the relevant authority.
2. If there is a local authority in the area, visit the authority or his/her representative to explain the project and the purpose of the mission.
3. Interview key stakeholders for existing information.

4.3.2. Research steps in an access town/major mining hub

1. Meet with local government administration officials (Ministry of Mines or regional administration or both). Note: some offices require that a letter be sent before arriving in person. Explain the project and purpose of the research project. Present the **project description** or **contract** if necessary.
2. If there is a local authority in the area, visit the authority or his/her local representative to explain the project and the purpose of the research mission.
3. If there is a gold trader in this access town, pay a visit for an interview.
4. Interview other key stakeholders for existing information.

4.3.3. Research Steps in an ASGM Community

1. Meet with the local authority or local administrator to explain the project and the purpose of your research visit. If requested, present your **project description** or **contract**.

2. If a significant number of miners reside in the village or camp, and if time permits, gather them together and explain the project, the purpose of your research visit and the type of research you plan to carry out (*i.e.*, explain what you will be doing). This is also a good opportunity to explain a little bit about what mercury is and why it can be dangerous. Leave time to listen to any concerns the miners express and respond to their questions.

3. Use the "**Community Interview**" form to document observations. Information collected at this stage may be quite general. That is okay. More detailed information will be collected from smaller groups of miners working in or near pits, shafts, or processing systems (described later in *Section 4.3.5*).

A Note About Field Forms

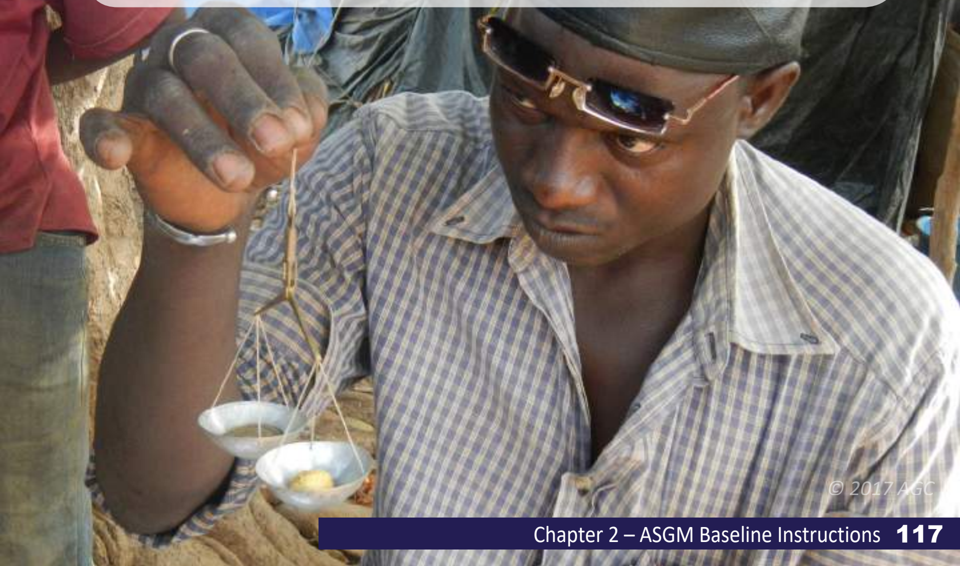
It is very important that on every form, the location information is 100% complete. Without this information, the data can not be traced back to its original location in the future and the integrity of the final results will be compromised.

Location Information			
Country		ASGM Mining Region	
Province / State / Department		ASGM Site	
County / District		Latitude	
Concession / Mining Title		Longitude	
Community		GPS device & datum	

4.3.4. Gold Traders

Small gold buying and trading houses may be found operating on a regional scale in the capital and access towns or on a local scale in an ASGM community or site. Be mindful that gold buyers and traders may be secretive about some information, especially that which relates to mercury use and sale and ASGM activities that are illegal/informal. Therefore, be thoughtful about these interviews. If feasible, buying a small amount of gold is a great way to gain trust and get information; you can document the price paid, get them to test for purity, ask them where it came from, and who produced it. (Note: inquire with the appropriate authorities beforehand to check the legality of buying gold. Some countries require a licence to do so. Use good sense to judge whether purchasing gold is allowed by the country and whether it will help or hinder the research goals and how locals interpret the project).

Regarding questions about mercury, it may not be effective to lead by asking about mercury and, depending on the context, you may need to discover information about mercury indirectly. View the gold for clues about mercury use. If it is sponge gold, you know that mercury has been used. If it is gold flake or powder, you know that gravitational methods have been used and likely no mercury was used for at least that portion of gold (fllake gold is not evidence that all gold production is mercury-free. It may be that coarse flake gold is produced without mercury and fine gold is produced with mercury.). If it is a gold doré, it means the gold has been smelted and so the means of production is unknown.



Sponge gold: The gold has been processed with mercury. The sponge texture is what remains after vapourizing mercury from a gold-mercury amalgam.

Gold flakes or powder: This gold has likely not been processed with mercury. Flake gold is usually an indication that gravitational methods have been used (*e.g.*, panning, sluicing and panning, shaker table). Remember, fllake gold is not evidence that all gold production is mercury-free. It may be that coarse flake gold is produced without mercury and fine gold with mercury.

Gold doré: The gold has been smelted (melted down) and possibly refined (purity increased). There is no way of knowing how the gold was originally processed.

Research Steps at a Gold Trader

1. Meet with the gold trader to explain the project and the purpose of your research visit. If requested, present your **project description** or **contract**.

2. Interview the gold trader, referring where necessary to the "**Gold Trader Interview**" form. You don not have to follow the same order as the form. In fact, it is best to start with questions about gold (the price of gold, quantities purchased, different types of gold) or respectful small talk (*e.g.*, ask about her/his "story" about becoming a trader or how business is going). However, make sure that by the end of the interview you have all the information necessary to fill in all fields in the form.

3. If possible, ask the gold buyer if you can see some gold. Note whether it is flake, powder, sponge gold, or doré. If you can, take a photo.

4.3.5. Research Steps at an ASGM Site

1. ***Introduce yourself, the team, and the project***

   On arrival, introduce the team and the project. State that the project is non-profit and focused on improving the health, environment, and livelihoods of artisanal miners through the reduction of mercury exposure. Emphasize that participation is entirely voluntary. Take time to ensure participants understand the goal of the baseline work (better understanding of miner populations, gold production, mercury use, processes applied, and the sector in general) and answer any questions about the work. This initial conversation is important in gaining trust with miners and gauging their ability and desire to help. Most owners and operators are happy to participate and often keen to demonstrate their knowledge of the workflows. An informal and casual approach is generally most successful, but each researcher will develop their own effective approach.

2. ***ASGM Site Observations Form***

   Fill out the field form: "**ASGM Site Observations**," which provides prompts for information collected via preliminary observation and counts, *e.g.*, mining/processing techniques, system counts, and mineralogy.

3. ***Conduct interviews at extraction units and processing systems***

   Next, approach specific pits, shafts, or processing systems. Identify group leaders and interview them. If not present, interview the miners/operators. Use the forms: "**ASGM Site Interview: Extraction**," "**ASGM Site Interview: Transport**," and/or "**ASGM Site Interview: Processing**" to record feedback. If possible, have **two field researchers** conduct an interview together. Having two researchers ensures a continual flow to the conversation, all questions are asked, discrepancies in the information are identified, and quick calculations are performed without having to stop the interview.

4. ***Physical measurements***

   Conduct the necessary physical measurements as outlined in the research plan. If you are at an extraction unit, you may weigh multiple sacks of ore to find the average weight. If you are at a processing unit, you will weigh mercury and gold inputs and outputs throughout the processing method to find the Hg:Au ratio.

The research steps differ slightly between extraction and processing sites. Steps specific to each are outlined in the following two sections.

At an Extraction Unit (mine pit or shaft)

1. Go to a specific pit or shaft. Identify the miners from this pit or shaft. Introduce yourself to the miners (and their pit boss, if there is one). Explain the project and the purpose of your research visit.

2. Observe the ore extraction method. Briefly describe this work flow in your notes or on the "**ASGM Site Observations**" form, including how the ore is transported and where it seems to be taken for processing.

3. Interview the pit/shaft boss and miners from that pit or shaft. The goal is to gather information specific to that pit or shaft. If miners from other pits gather around, focus on miners working in the current pit or shaft.

   Remember to start with easy and straightforward questions (How do you dig? What kind of equipment do you use?) before moving on to more important questions about production (how many sacks a day do you produce?) and then complicated questions about earnings (How are sacks/gold divided among team members? How much does a miner make per week?). Try to conduct interviews with business, concession, and land owners as well. Record the feedback on the field form: "**ASGM Site Interview: Extraction**;" one form per interview.

4. If there is sufficient time, oberservation of an extraction unit (with researchers taking shifts) over an entire shift is an effective strategy to cross-check the daily ore production figures stated in interviews. Record the observations from the "sit-in" on the "**ASGM Site Observations**" form.

At a Processing Unit (washing area, sluicing area, milling area, or similar)

1. Go to a specific processing system. Meet with the processing boss and operators to explain the project and the purpose of your research visit.

2. Observe the ore processing method, from sacks of ore to processed gold. Briefly describe this work flow in your notes or on the "**ASGM Site Observations**" form, noting the steps, the equipment, and where mercury is used. (Refer to *Chapter 1, Section 1.6 - Processing* to review the steps in a standard processing work flow).

3. Visit each of the steps in the processing work flow and interview the workers about their work. Use the form: "**ASGM site Interview: Processing**" to record the feedback.

4. Find the mercury-gold (Hg:Au) ratio of the system by revisiting each step where mercury is added /recovered or gold is produced and weighing the inputs and outputs. Follow the procedure outlined in the following section, *4.5.8. Research steps to measure a mercury-to-gold ratio at a processing site (p. 124*). Record your measurements and on the "**Mercury-to-Gold (Hg:Au) Ratio**" form. Since many circumstantial variables can affect the Hg:Au ratio, conduct at least three trials to define its range.

5. If there is sufficient time, oberservation of a processing unit (with researchers taking shifts) over an entire processing cycle or worker shift is an effective strategy to cross-check interview feedback on the ore throughput, number of workers, and processing cycle time for the unit. It also presents the opportunity to measure multiple Hg:Au ratios for the same unit to capture its variation (at least three mesaurmenets are recommended for a robust result). Note that some units have a much faster processing rate than others; one cycle may be as short as one hour or as long as 24 hours. Record the observations from the "sit-in" on the "**ASGM Site Observations**" form.

4.3.6. Research Steps to Measure a Mercury-to-gold (Hg:Au) Ratio at a Processing Unit

To review the concept of the mercury-to-gold ratio, how it is applied, and which variables to measure, where, and why, see *Chapter 1, Section 7.4 (p. 67).*

The average ratio for each processing type will eventually be multiplied by its annual gold production (for a site, region, or country) to get its annual mercury-use.

To find a Hg:Au ratio, measurements are made in the mercury mix phase and the amalgam heating phase. Record all measurements on the "**Mercury-to-Gold Ratio (Hg:Au)**" form.

Tips for using the Hg:Au Form

Use a different copy of the Hg:Au Ratio Form for each processing type on the processing site. This is because each different processing type has a different Hg:Au ratio (*i.e.*, a different ratio for sluice-concentrated amalgamation, pan-concentrated amalgamation, whole ore amalgamation in different types of mills *etc*.).

Conduct several trials (at least three) on the same processing type (single Hg:Au Ratio Form) to measure its Hg:Au ratio at least three times. This is because many factors affect the Hg:Au ratio (*e.g.*, worker skill, minerology, ore type, angle of sluice). Doing several trials ensures the average and range of the ratio are well defined.

The Mix Phase (Measuring Liquid Mercury)

First, measure how much mercury is used in the mix. The basic steps are:

1. Weigh the liquid mercury added to the ore.
2. Weigh the mercury recovered from the ore, (contains amalgam and excess liquid mercury).
3. Weigh the excess liquid mercury after the squeeze to separate the amalgam.

Where you do the measuring will depend on the processing technique (see panel below). In either case, the measuring technique and data form "**Mercury-to-Gold Ratio (Hg:Au)**" are the same.

Whole ore amalgamation work flows:
In whole ore amalgamation processing, mercury is added to the ore before it has undergone any concentration, often during the milling stage, and tends to use a lot more mercury than concentrate amalgamation. In an alluvial set up, the mercury might be added to milled powdered ore and water in a basin and stirred until the mercury and gold join. In a small-scale mechanized set-up, the mercury might be poured in to a sealed ball mill together with water and ore.

Concentrate amalgamation work flows:
In concentrate amalgamation, the ore is first concentrated and then mercury is added. In an alluvial setup, a 50-kg sack of powdered ore might be run through a sluice to produce a single basin of gold concentrate. This concentrate may then be mixed in a basin with water and mercury to produce an amalgam. In a small-scale mechanized setup, the ore might be milled and run through a sluice and then a shaking table adding mercury.

Good field measuring techniques are important here. You should have an electronic balance (scale) that you have placed on a level surface, out of wind and rain. Also, it is important to explain to the miners what you will be doing. Miners will be providing you with their mercury and gold to weigh, so it is important that they understand and wish to cooperate. Time spent beforehand explaining the purpose of the research and the steps you will be taking is time well spent.

(i) Weigh the liquid mercury added to the ore or ore concentrate

Since mercury always comes in a container, **weigh the mercury and the container together**; this is **(A)** on the **Hg:Au Ratio Form**. If the mercury comes in a syringe, pen cap, or bottle weigh the syringe, pen cap, or bottle when it is full of mercury. Then, after the miner has added the mercury to the ore, **weigh the empty container (B)**. When doing many trials, weigh the container every time – do not assume it is always the same weight. Make sure you weigh the actual container used and immediately after the mercury is added – do not weigh another bottle, syringe, or pen cap and assume the weight is the same. Sometimes, miners use only a portion of the mercury in the storage container. In that case, it is helpful to have containers on hand (cut water bottle bottoms, pen caps, *etc*., depending on the amount of mercury being added). Ask the miners to pour the amount of mercury they intend to use into your container. It is still important to weigh the empty container before and after the mercury measurement.

- Subtract the mass of the empty container from the mass of the container with mercury **(A-B)** to get the **mass of the mercury added to the ore (C).**

(ii) Weigh the mercury recovered from the mix, which contains the amalgam and excess liquid mercury

Next, weigh the mercury recovered from the mix. This mercury is separated from the mix using gravity (washing, panning). When the volumes are smaller (*e.g.*, when the mix is done in a basin or pan), a puddle of the mercury amalgam will form on the bottom of the basin. This puddle contains both the amalgam and excess liquid mercury that did not amalgamate. Typically, miners will collect this mercury in a container (*e.g.*, a syringe, bottle, or bowl). The trick in this step is to **weigh the empty container before the miner recovers the mercury (D)**. Once the miner recovers the mercury, **weigh the container with the mercury in it (E)**.

- Subtract the mass of the empty container from the mass of the container with mercury **(E-D)** to get the **mercury recovered from the mix phase (mercury and amalgam) (F)**.

Note: The mercury here is often recovered with some water. Since you want the mass of the mercury without the water, you can remove the water before weighing. A sponge or small sponge-towel easily soaks up water without soaking up mercury.

(iii) Weigh the liquid mercury recovered (squeezed out) from the mix

Next, the miners will capture this mercury and squeeze it through a fine cloth, often more than once. The solid amalgam ball will remain in hand in the cloth and the non-amalgamated liquid mercury will pass though the cloth and collect in the basin. **Weigh this un-amalgamated liquid mercury recovered from the squeeze (I).**

Note: The gold-mercury amalgam ball will be retained by the miner for the vaporizing process. This will be weighed in the next step.

Measurements During Mix Phase

(i) Weigh the mercury added to the ore (C);

(ii) Weigh the mercury recovered from the mix, which contains the amalgam and excess liquid mercury (F);

(iii) Weigh the mercury recovered (squeezed out) from the ore (I)

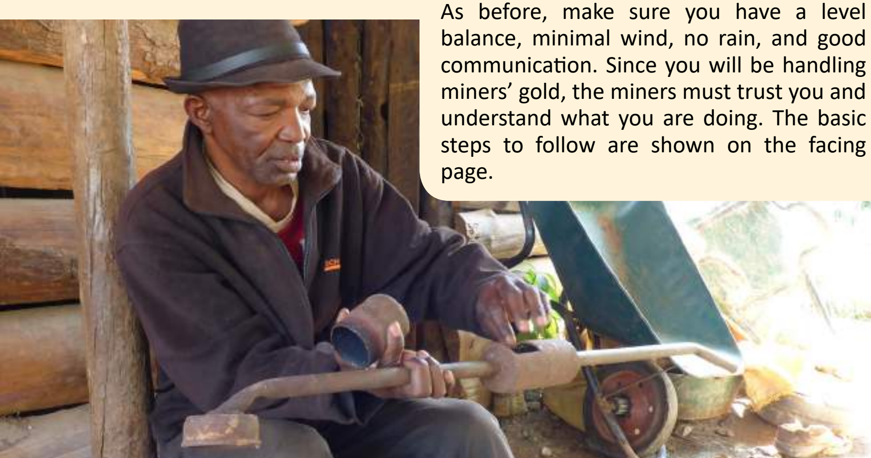
The Amalgam Heating Phase (Measuring Amalgam, Sponge Gold, and Liquid Mercury Recovered in Retort)

What comes out of the mix process after the squeeze is a silver-coloured ball of mercury-metal amalgam, which includes gold. These amalgam balls range from pea- to lime-sized, depending on the quantity of metals extracted from the ore. Miners subject this amalgam to heat to vaporise most of the mercury. What is left after heating is a lump of bronze-gold material with a porous surface called sponge gold. Some of the evaporated mercury may be recovered in a retort[1]. If no retort is used, then all will enter the atmosphere as mercury vapour. However, because retorts leak and become contaminated objects, operators will still be exposed to mercury vapour and some mercury will still be lost to the environment as mercury vapor[1]. The goal of this step is to determine the mass of this escaping vapor.

Although it is virtually impossible to measure, a small amount of residual mercury will remain in the sponge gold and will be released to the atmosphere during smelting and further refinement. The larger the ball of amalgam is, the greater the amount of residual mercury will be in the remaining sponge gold. This is the same concept as cooking. It takes longer for heat to get to the centre of a large mass than a small one.

Note: The Hg:Au Ratio form has spaces for recording the mass of the containers; it is up to the field researcher to decide whether these are truly necessary. Often, both the amalgam and sponge gold are solid, self-contained lumps that can easily be weighed on a portable field balance. In these cases, weighing the container is unnecessary. However, at times when the amalgam is kept in or heated in a specific container, the spaces on the form are useful.

As before, make sure you have a level balance, minimal wind, no rain, and good communication. Since you will be handling miners' gold, the miners must trust you and understand what you are doing. The basic steps to follow are shown on the facing page.

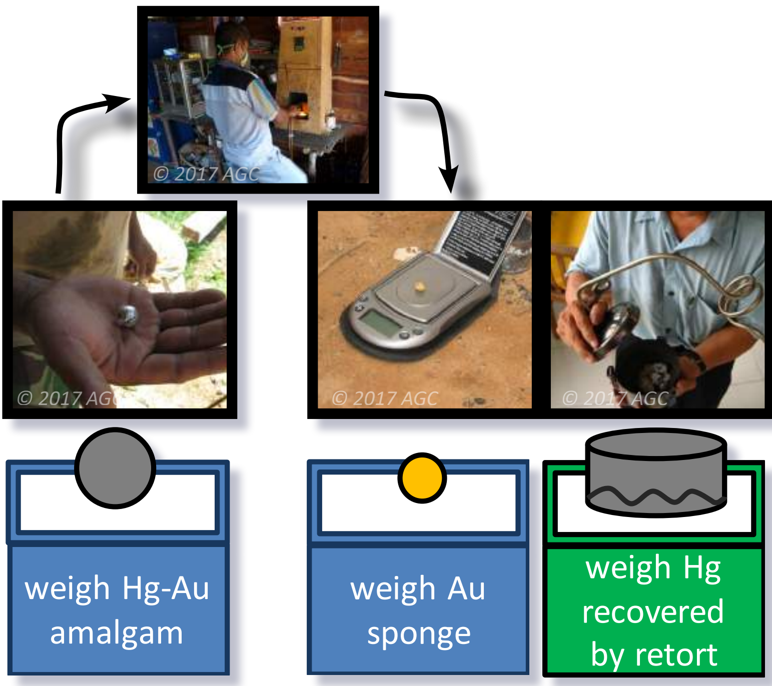


[1] To learn more about retort practices, see AGC, 2014. "Using Retorts to Reduce Mercury Exposure in Artisanal and Small-Scale Mining: A Practical Guide.", available at www.artisanalgold.org.

Measurements During Amalgam Heating Phase

(i) Weigh the solid ball of amalgam before burning (L);
(ii) Weigh the sponge gold after burning (O);
(iii) Subtract (L-O) to get the mass of mercury evaporated (Q).

<u>If a retort is used</u>:
(iv) Ensure there is no mercury in the retort before the heating;
(v) Weigh an empty container for Hg from the retort (R);
(vi) Allow miner to recover the mercury accumulated in retort;
(vii) Weigh the container with recovered mercury (S);
(viii) Subtract (S-R) to get mercury recovered by retort (T)
(ix) Subtract (Q-T) to get the mass of mercury lost to the air during the heating phase (W).



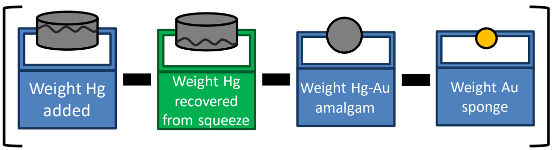
Summary Calculations

Once all the measurements have been made, the Hg:Au ratio can be calculated and a number of other informative calculations can be made.

V. Mercury Lost to Tailings in Mix Phase (Hg:Au Ratio Form, entry V.)

Calculate the amount mercury lost to the environment during the mix phase as liquid mercury in the tailings.

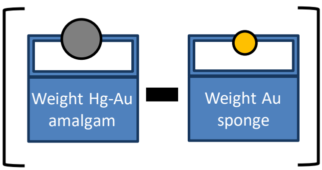
Mercury Lost to Tailings in Mix Phase



Q. Mercury Evaporated in the Heating Phase (Hg:Au Ratio Form, entry Q.)

Calculate amount of mercury that evaporated when the amalgam was heated.

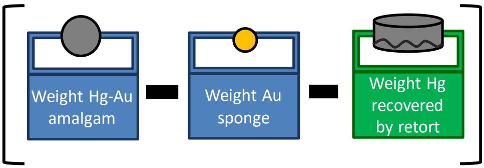
Mercury Evaporated in Heating Phase



W. Mercury Lost to the Air in Heating Phase (Hg:Au Ratio Form, entry W.)

Calculate the amount of mercury lost to the environment during the heating phase as vapour to the air. than solid mercury.

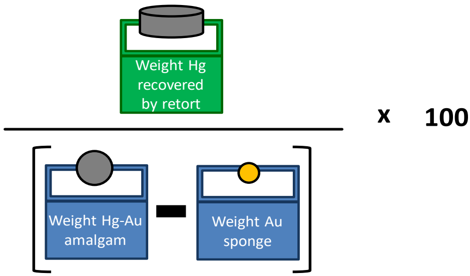
Mercury Lost to Air in Heating Phase



U. Retort Efficiency (Hg:Au Ratio Form, entry U.)

The retort efficiency gives an indication of how effectively the retort system recovers mercury. Even very basic retorts should manage a recovery ratio of 50%.

Retort Efficiency (%)



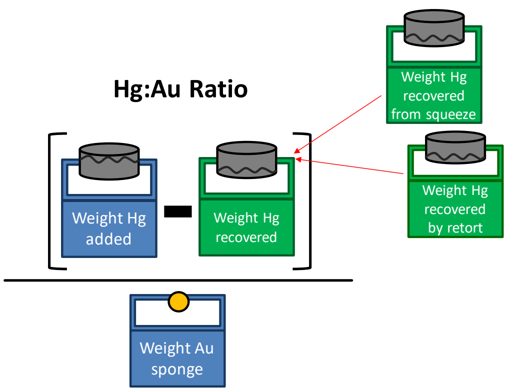
X. Total Mercury Used (Hg:Au Ratio Form, entry X.)

The total amount of mercury used is the total amount of mercury that was lost to the environment, both in the mix phase as liquid to the tailings and in the heating phase as vapour to the air. **(V + W)**

Y. Mercury-to-Gold (Hg:Au) Ratio (Hg:Au Ratio Form, entry Y.)

The Hg:Au ratio is simply the mass of total mercury put into the environment during this process (total mercury used) divided by the mass of sponge gold in pure gold (100%, 24K) equivalence. The formula for total Hg used is given in the previous equation. For the conversion into pure gold equivalence, see *p. 5*. In summary:

Hg:Au Ratio



Step 5 – Preliminary Data Analysis: Identifying Data Gaps, Revising Methods, and Returning to the Field

Now that a first session of data collection has been completed in the region, it is time to conduct preliminary analysis of the data to determine baseline estimates of ASGM workforce, gold production, and mercury use for the region.

Calculate the ASGM baseline estimates for the region from the field data by following Steps 6 through 8 on the following pages. Triangulate regional estimates from as many sources as possible. Show the results to stakeholders. Together, identify data gaps, errors, and estimates that have low confidence.

Return to the field to capture data to fill gaps and increase confidence in the estimates.

Repeat steps 6 through 8, conducting data analysis, having the results reviewed by an expert and by relevant stakeholders, adapting the methods, and returning to the field until robust, high-confidence regional estimates are achieved.

Step 6 – Data Analysis 1: Calculating Site-specific Key Information and Baseline Estimates

Now that data has been collected in the field (whether it is the first, second, third, or final round), it is time to compile the data and use it to produce site-specific key information.

This section will guide you to:

- Compile the data acquired in the field using the database;
- produce site-level baseline estimates;
- produce averages of common variables that can be coupled with regional information to produce regional estimates.

Background reading:

- Chapter 1, Section 7: Approaches for Estimating Mercury Use (p. 66)
- Chapter 1, Section 8: Producing National Estimates from the Data (p.79)

Supporting tools used in this step:

- Data collection forms:
  All, from Step 4
- Data synthesis and analysis tools (Annex A3):
  ASGM_site(s).xlsx
- Example work:
  Equations and Example Calculations (Annex A4)

6.1. Data Entry: Using the Excel Workbook for a Site

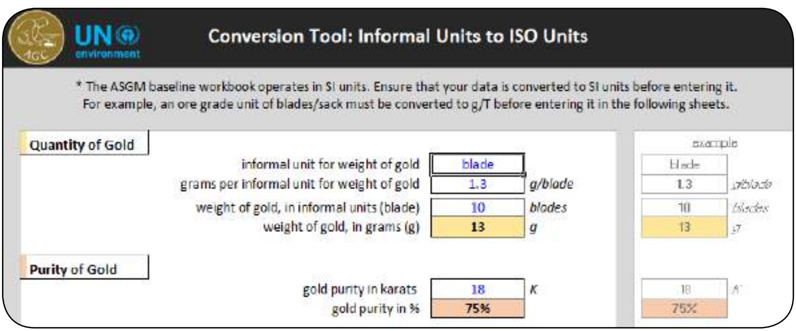
The **ASGM Site Workbook (ASGM_site.xls)** is a collection of spreadsheets that stores the field data and assists to calculate averages of common variables and baseline estimates (workforce, gold production, and mercury use) for a single site. The workbook can be opened in Microsoft Excel or in Apache OpenOffice Calc, which is an open source and free software.

Open ***ASGM_site.xlsx*** and rename the file with the site name, *e.g.*, *"**ASGM_site_Placerton.xlsx**"*. At the end of every field day, the Field Researchers enter their field data into this workbook and calculate site-level variables and baseline estimates to ensure that the necessary data has been collected.

Note: All data entered by researchers will appear in blue font. All information that is automatically calculated from the given data will appear in **black font**. Also note that, upon initial download, all workbooks contain example data (in blue) as a guide for how the data might look. **Delete this data before starting your site analysis.**

Sheet 0 – SI Unit Converter

The ASGM data workbooks operate in formal SI units. SI units are mL and L for volume; g, kg, and T for weight; and % for purity. Often, information from ASGM sites is expressed in informal units. Informal units for volumes or weights used in production may be bottles of mercury or bags or sacks of ore. Informal units of weight for gold may be blades or coins of gold. Informal units for ore grade might be "blades per sack" rather than the formal "g/T." Before entering data into the workbooks, make sure that you are reporting in SI units. If not, the first sheet in the ASGM Site Workbook "***0-Unit Conversion***" contains a simple conversion tool to help convert data from informal to SI units before entry.



Sheet 1 – Location Information

Note: It is very important that for each entry, the location information is 100% complete so the data can be tracked to its source.

ASGM Site: Placerton | Location Information

ASGM Site	Placerton	Associted Communities	Korfalo Village
Concession/Mining Title	-	County / District	Malika District
ASGM Mining Region	Goldu	Province / State / Department	Goldu Province
Lat	1.216667	Country	Goldaguay
Long	123.500000		
GPS device & datum	Trimble handheld GPS, NAD83		
Date(s) of data collection	Oct 26-30, 2017	Name of field researcher(s)	Marie Cooke
Site contact(s): name	Ana Fleur	Eli Strong	Jimmy Jones
role	Community Chief	Mining Coordinator	Cooperative Leader
phone number	1(234)567-1234	1(234)567-8910	
email			jjones@email.com

Sheets 2 – 7 – Data Entry, Analysis, and Site-level Information Summary:

The next seven sheets are data entry tables for your field data. Each sheet represents one type of field form (**2-Community, 3-Gold Trader, 4-ASGM Site Observations, 5-ASGM Site Interviews-Extraction, 5-ASGM Site Interviews-Transport, 5-ASGM Site Interviews-Processing, 6-HgAu Ratio measures)**. The results from one field form go into one column of the sheet for that type of form. For example, the results from your first community interview form are entered in the "Community 1" column of the Community sheet. The results from your first gold trader interview are entered into the "Interview 1" column of the Gold Trader sheet.

On a single sheet, when all field data has been entered, the statistics for site-level variables (average and range) will be automatically calculated in the last two columns of the sheet. Baseline estimates will be caclulated in the final rows of the sheet. The variable statistics and baseline estimates from all sources (all sheets) are automatically compiled for comparison in the final sheet: ***7-Site Summary***.

> In the ***ASGM_site.xlsx*** workbook, the ***7-Site Summary*** sheet is generated from the data entered into sheets 2 through 6. It summarizes the site variable statistics and baseline estimates for the site based on the field data collected.

On the **7-Site Summary** sheet, check the following:

(a) Check to ensure that site-specific variables have been calculated correctly and that they make sense via a geological lens, income lens, and good background knowledge of the sector. It is best if each variable has been calculated by at least two independent methods (*e.g.*, using extraction and processing data), so that cross-checking can be done.

Key Variables at Placerton

source	Gold Trader Interview	
	Mean	Range
Mineralogy		
ore grade (g/T)	**6.0**	2 – 10
gold purity (%)	**80%**	70 – 90%
Trade		
price per g of pure gold (local currency/g 24K Au)	**38.00**	38 – 38
price per kg of mercury (local currency/kg Hg)	---	0 – 0
purchased by miners per year, mercury, entire site (kg Hg/y)	---	0 – 0
purchased by sellers per year, mercury, entire site (kg Hg/y)	---	0 – 0
	Site Interviews	
	Mean	Range
Extraction Type 1		
daily extraction per miner (T ore/shift)	**0.1**	0.1 – 0.1
average active miners per unit	**10**	10 – 10
shift length (hr)	**8**	8 – 8
shifts per day	**2**	2 – 2
days active per year (d/y)	**200**	200 – 200
daily earnings per miner (g 24K Au)	**0.5**	0.5 – 0.5
annual earning per miner (g 24K Au)	**110**	100 – 120
daily ore extraction per unit (T ore/d/unit)	**2.0**	2 – 2
value produced yearly per miner (local currency/y/miner)	**5,110**	**4900 – 5320**
Processing Type 1		
ore throughput per unit per shift (T ore/shift/unit)	**0.4**	0.4 – 0.4
average active workers per unit	**4**	4 – 4
shift length (hr)	**8**	8 – 8
shifts per day	**2**	2 – 2
days active per year (d/y)	**200**	200 – 200
daily earning per worker (g 24K Au)	**0.5**	0.5 – 0.5
annual earning per worker (g 24K Au)	**90**	80 – 100
pure gold sold from unit per month (g 24K Au/mo)	---	0 – 0
mercury bought for system per month (kg Hg/mo)	---	0 – 0
Hg:Au Ratio (estimated by miners)	**7.5**	5 – 10
Hg:Au Ratio (physically measured)	**6.87**	6.39 – 7.6
daily ore throughput per unit (T ore/d/unit)	**0.8**	0.8 – 0.8
value produced yearly per worker (local currency/y/miner)	**5,110**	4900 – 5320

(b) Below the variable summary table in blue are baseline estimates for the site based on each approach. This summary includes annual gold production, annual mercury use, and site workforce (note that these are also found at the bottom of each data entry sheet). Check that the estimates have been calculated correctly by checking formulas and cell references carefully. Ensure that each estimate has been calculated via at least 3 independent approaches (*e.g.*, processing data, earnings data, and official trade data). Triangulate the three (or more) estimates. Decide which estimates are low confidence and either update the estimate through additional investigation or remove it from the average. If removing an estimate, the Baseline Lead **must** provide reasonable justification.

Site-Level Baseline Estimates for Placerton

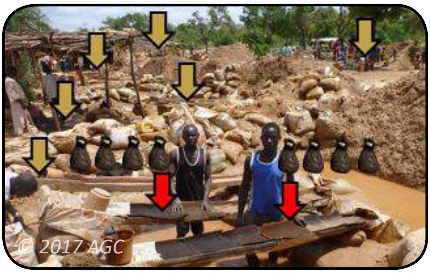
		Mean	Range
ASGM Ore Production (T 24-K Au/y)		Mean	Range
	Extraction-based	20,800	18000 – 23600
	Processing-based	20,940	19000 – 22880
	Transport-based	4,560	4000 – 5120
	average	15,433	
ASGM Gold Production (kg 24-K Au/y)			
	Extraction-based	59.3	53 – 65
	Processing-based	58.9	55 – 63
	Transport-based	31.9	28 – 36
	Trade-based (bought by gold traders)	25.6	25 – 26
	average	**50.0**	
ASGM Mercury Use (kg Hg/y)			
	Extraction-based	252	
	Processing-based	250	
	Trade-based (total sold by Hg sellers)	---	0 – 0
	Trade-based (total bought by miners)	---	0 – 0
	Transport-based	136	
	average	**213**	
Workforce			
	Extraction Workers (extraction-based)	430	400 – 460
	Processing Workers (processing-based)	408	400 – 416
	Transport Workers (transport-based)	30	28 – 32
	total	**868**	

If the collected data are insufficient to produce site-based variables and baseline estimates or if the cross-checks yield very different values for any of these variables, adjust the field methodology for the following day to collect better data. If the site summary is showing site-level variables and baseline estimates that make sense based on expert knowledge and cross-checks between approaches show agreement, the site is complete.

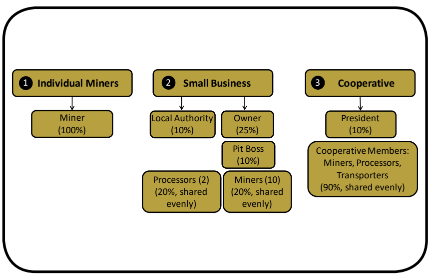
6.2. Calculating Key Information for an ASGM Site

Key variables are calculated from raw data collected on a site. Key variables are important because they enable data to be generalized across sites with similar characteristics (the same extraction or processing methods) that you are unable to visit. This section provides suggestions of data that should be collected, key information that can be calculated, and how to carry out the calculations, using three example approaches:

Extraction-based Approach



Processing-based Approach



Earnings-based Approach

6.2.1. Calculating Site-level Information and Baseline Estimates: Extraction-Based Data

An extraction-based approach uses information collected about ore extraction to produce estimates of ASGM gold production and workforce. To carry out this approach, the baseline team must gather information about the number and type of extraction units in the region, the typical ore production per extraction unit or per miner, the number of extraction units or miners per site, and a piece of regional information for extrapolating site-based data to regional estimates. Mercury use is then determined by multiplying gold production by a known Hg:Au ratio(s) specific to the processing method(s) used on the extracted ore.

Important Considerations

When the Hg becomes too dirty to use, it gets thrown away. This loss is not accounted for by this method. Asking processing centre owners how much mercury they buy weekly and/or monthly to replenish what they have used may give a rough indication.

Where to collect data on site: Site leaders, group leaders, mining bosses, pit bosses, extraction workers, transportation workers.

Where to collect data off-site: Gold buyers/trade rs, site-level stakeholders, National Level ASGM Sector Scoping Report.

Definition of an extraction unit: The most basic unit of miners on a mining site. Field data on ore extraction (*e.g.*, extraction rate) are measured per extraction unit and can then be scaled up to site- or regional-level estimates if the total number of units in the site or region, respectively, is known. Examples of extraction units: number of miners in an open pit, a shaft, a tunnel, a group of surficial material miners, or other type of mining group.

What must be known ahead of field data collection:

- An understanding of the mining work flow and the number and style of mining techniques present in the region (*i.e.* the types of extraction units);
- An average Hg:Au ratio specific to the ore type and processing method(s) found in the region. This ratio is found via physical measurements, miner surveys, or both;

Information collected on the extraction site:

- Average number of workers in an extraction unit (workers/unit)
- Number of active extraction units on the ASGM site (units/site)
- Number of active extraction days per year (d/yr)
- Daily ore production rate per extraction unit (T/d/unit)
- Average ore grade (g/T)
- Average gold purity (%)

Information collected off-site:

- average ore grade and gold purity from gold trader interviews.

Information collected off-site:

- Number of extraction workers on the ASGM site
- Annual gold production per extraction unit (g/y/unit)
- Annual gold production per extraction worker (g/y/worker)
- Annual gold production for the site (g/y/site)

<u>Steps at each ASGM site (extraction units)</u>:

1. Visit the ASGM site and understand the organization of the extraction workers on the site. Define the key extraction units.

2. Count or interview for the average number of workers in an extraction unit. Count or interview for the number of extraction units on the ASGM site that are actively being worked. Calculate the total number of extraction workers on the ASGM site as the product of the two.

3. Interview mining bosses, group leaders, miners, for daily ore production rates per extraction unit, average ore grade, and gold purity. (If ore production is reported per individual miner, scale up to extraction unit with the average number of miners working an extraction unit). Multiply all to get the daily gold production for an extraction unit. Scale up to daily gold production for the site by multiplying the number of active extraction units on the site. (or scale down to daily gold production per extraction worker by dividing the average number of workers in an extraction unit).

4. Multiply by number of active days per year to get annual gold production on the site.

5. Cross-check interview results or fill in data gaps with physical measurements.

<u>Steps off-site:</u>

1. Survey gold buyers for daily ore production rates, average ore grade and gold purity. Use these to cross-check with the results of extraction site interviews.

orange text = raw field measurement or observation
blue text = calculated variable

6.2.2. Calculating Site-level Information and Baseline Estimates: Processing-based Data

A processing-based approach uses information collected about ore processing to produce regional estimates of ASGM gold production, mercury use, and workforce. To carry out this approach, the baseline team must gather information about the number and type of processing units in the region, the typical throughput of each processing unit type, the number of processing units per site, and a piece of regional information for extrapolating site-level data to regional estimates. Mercury use is then determined by multiplying gold production by the Hg:Au ratio(s), measured on site, that are specific to the processing method(s) used to produce the gold.

Important Considerations

Since this method is based around reporting from artisanal processing, it does not account for artisanally extracted ore that is processed by large scale mining (LSM) industrial cyanidation. If the throughput of LSM industrial cyanidation is not considered, there will be no effect on the regional estimate of mercury usage (as no mercury is used in cyanidation), but there will be an underestimation of the total ore extraction and miner population. Also, when the Hg becomes too dirty to use, it gets thrown away. This loss is not accounted for by this method.

Where to collect data on site: Site leaders, group leaders, processor bosses, processors/system operators.

Where to collect data off-site: Gold buyers/traders, site-level stakeholders, National Level ASGM Sector Scoping Report.

Definition of a processing unit: The most basic unit of ore processors on a processing site. Field data on ore production (*e.g.*, throughput, gold production, mercury use) are measured per processing unit and can then can be scaled up to site- or regional-level estimates if the total number of units in the site or region is known. Example of a processing unit: a system that includes a crusher, ball mill, and sluice.

What must be known ahead of field data collection:

- The types of processing units present in the region and an understanding of the work flow for each;
- Processing shift lengths;
- Whether there are LSM-operated cyanidation plants in the area. These plants process artisanally mined ore and therefore their throughput must be included in miner population and gold extraction estimates (but not Hg-use, as LSM cyanidation uses no Hg);

Information collected on the processing site:

- Average number of workers per shift on a processing unit (workers/unit)
- Number of active processing units on the ASGM site (units/site);
- Average daily ore throughput of a processing unit (T/d/unit)
- Number of shifts per day
- Number of active processing days per year (d/yr)
- Average ore grade (g/T) and gold purity (%) on the ASGM site
- Average gold produced per processing unit per cycle (g/cycle/unit)
- Average mercury used per processing unit per cycle (g/cycle/unit)

Information collected from off-site:

- Average ore produced per extraction worker (kg/miner/d) - from extraction unit interviews and observations.
- Average ore grade, and gold purity - from gold trader interviews

Key site-specific information calculated from the data:

- Number of processing workers on the ASGM site
- Average gold produced per cycle for a processing unit (g/cycle/unit)
- Average gold produced annually for a processing unit (g/y/unit)
- Gold produced annually on the ASGM site (g/y/site)
- Average mercury used per cycle for a processing unit (g/cycle/unit)
- Average mercury used annually for a processing unit (g/y/unit)
- Mercury used annually on the ASGM site (g/y/site)
- Hg:Au ratio for each system type

orange text = raw field measurement or observation
blue text = calculated variable

<u>Steps at each ASGM site (processing units)</u>:

1. Visit the extraction site and understand the organization of the workers on the site. Define the key processing units.

2. Count or interview for the number of active processing units on the site.

3. Interview for the average daily ore throughput of a processing unit, average number of workers per processing unit, number of shifts per day, average ore grade, and gold purity, and average gold produced and mercury used per processing cycle. Combine to deduce daily gold production and mercury use for a processing unit. Scale up to daily gold production and mercury use for the site using the number of active processing units on the site.

4. Multiply by number of active days per year to get annual gold production.

5. Calculate the Hg:Au ratio for each processing system type by dividing the mercury used per processing cycle for the processing unit type by the gold produced per cycle for the processing unit type.

6. Cross-check the values in steps three and four with physical measurements where possible. In the case of the Hg:Au ratio, conduct the measurements at least three times per processing unit type and average. Measure all variables in step three by observing an entire processing cycle.

7. Multiply the annual gold production on site by the Hg:Au ratio to get the annual mercury use on site.

orange text = raw field measurement or observation
blue text = calculated variable

6.2.3. Calculating Site-level Information and Baseline Estimates: Earnings-based Data

An earnings-based approach uses information collected about stakeholder income to produce an estimate of ASGM gold production or workforce. To carry out this approach, the baseline team must gather information about the distribution of revenue between stakeholders for a specific venture (extraction/processing unit, business, ASGM site), and the number of a certain type of stakeholder (*e.g.*, extraction workers or mine owners) to produce an estimate of total earnings. If earnings are reported in grams of gold, then the estimate of gold production is known. If it is in local currency, an understanding of average gold purity will yield gold production. Mercury use is then determined by multiplying gold production by a known Hg:Au ratio(s) specific to the processing method(s) used to produce the gold.

Important Considerations

*The total daily and annual earnings per site and the revenue distribution (marked with an * below) are difficult to ascertain with accuracy and for that reason, the earnings-based method is less accurate than the extraction and processing-based methods. Also, when the Hg becomes too dirty to use, it gets thrown away. This loss is not accounted for by this method.*

Where to collect data on site: Site leaders, group leaders, processor bosses, processors/system operators, land owners, business owners, co-op directors.

Where to collect data off-site: Gold buyers/traders, site-level stakeholders, National Level ASGM Sector Scoping Report.

What must be known ahead of field data collection:

- An average Hg:Au ratio specific to the ore type and processing method(s) found in the region. Found via physical measurements, interviews or both.

Information collected at each site:

- Understanding of the stakeholders on the ASGM site and number of each
- Annual earnings per worker (this can be miners, bosses, owners, *etc*.) (g Au/y)
- Percent of the site's total revenue distributed to all workers of this type (%)
- Average ore grade (g/T) and gold purity (%) on the ASGM site
- Number of workers on the ASGM site - OR - Annual gold production (total revenue) of the ASGM site

Information collected off-site

- Average annual earnings per stakeholder type throughout the region
- Common structures of revenue distribution throughout the region

Key site-specific information calculated from the data:

- Annual gold production for the ASGM site (g/site/y)
- Annual mercury use for the ASGM site (g/site/y)
- - OR - Number of workers on the ASGM site

Steps at each ASGM site:

1. Interview to find average ore grade and gold purity.
2. Interview to understand the breakdown of the stakeholders on the ASGM site and number of each, the annual earnings of a specific worker type*, percent of the site's total revenue distributed to all workers of this type*

   This information would most typically be: number of miners, annual income per miner, and proportion of the revenue distributed to all miners.

   Cross-check with the average annual earnings per worker and the common revenue distribution throughout the region.
3. Using these five variables, calculate annual gold production for the ASGM site. Apply known ASGM ratio(s) to find annual mercury use for the ASGM site.
4. – OR – if the number of workers is not known, but instead the annual gold production on the ASGM site is known, multiply by percent of revenue distributed to workers and divide by the average annual earnings per worker to get the number of workers on the ASGM site instead.

orange text = raw field measurement or observation

blue text = calculated variable

Step 7 – Data Analysis Phase 2: Calculating Regional Estimates

Now that site-specific variables, baseline estimates, and Hg:Au ratios are known, it is time to calculate regional estimates. This section introduces the spreadsheet tool that can be used to find a regional baseline estimate by either (1) summing the measured baseline estimates for all sites in the region OR (2) extrapolating key information from a subset of sites to all sites in the region.

This section will guide you to:

- Produce regional estimates from site-level estimates and key averages and known regional information through the process of extrapolation.

Background reading:

- Chapter 1, Section 7: Approaches for Estimating Mercury Use (p. 66)
- Chapter 1, Section 8.2: Extrapolating Regional Estimates (p. 80)

- ***Supporting tools used in this step:***

- Data synthesis and analysis tools (Annex A3):
  ASGM_site.xlsx
  ASGM_region.xlsx
- Examples:
  Equations and Example Calculations (Annex A4)

Note: This step is arguably the most important. It requires the most innovation to be successful. Since countries, regions, and sites can differ in technology and production, there is no standard step-by-step method for calculating regional baseline estimates that will work for all locations. Once regional estimates are calculated, they require review by an expert and by stakeholders.

7.1. ASGM Region Summary

Supporting Tool:

Open the workbook **ASGM_region.xlsx** and save with the name of the region, *e.g.*, "**ASGM_region_Goldu.xlsx**." This workbook summarizes the key information from all sites you have visited in one table. On completion of field data collection, you should have an **ASGM_region.xlsx** for every ASGM mining region in the country.

Note: All data entered by the researchers will appear in blue font. All information that is automatically calculated from the given data will appear in ***black font****. Also note that, upon initial download, all workbooks contain example data (in blue) as a guide for how the data might look.* ***Delete this data before starting your site analysis.***

7.1.1. Enter the Variable Summary for Each Site

The first sheet of the **ASGM_region.xlsx** workbook is called "**All Sites.**" *All Sites* is designed to hold the summary information for each site visited in the region. For each site, enter the site name at the top of the column, and below it, paste the yellow summary column from the **7-Site Summary** sheet of its ASGM_site.xlsx workbook.

ASGM REGION: Goldu

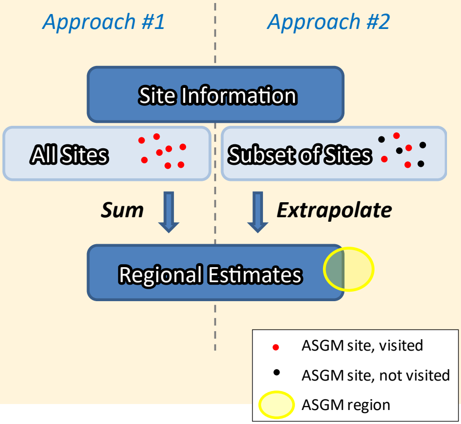
Region name: Goldu

Key Variable Statistics for ASGM Sites in Goldu

Variable	Site 1 *Placerton* *mean*	*range*	Site 2 *[site name]* *mean*	*range*	Site 3 *[site name]* *mean*	*range*
Mineralogy						
ore grade (g/T)	9.0					
gold purity (%)	73%					
Trade						
price per g of pure gold (local currency/g 24K Au)	37.25					
price per kg of mercury (local currency/kg Hg)	---					
purchased by miners per year, mercury, entire site (kg Hg/y)	---					
purchased by sellers per year, mercury, entire site (kg Hg/y)	---					
Extraction Type 1						
daily extraction per miner (T ore/shift)	0.1	0.1 – 0.1				
average active miners per unit	10.000	10 – 10				
shift length (hr)	8	8 – 8				
shifts per day	2	2 – 2				
days active per year (d/y)	200.0	200 – 200				
daily earnings per miner (g 24K Au)	0.5	0.5 – 0.5				

7.1.2. *Sum or Extrapolate Depending on Number of Sites Visited*

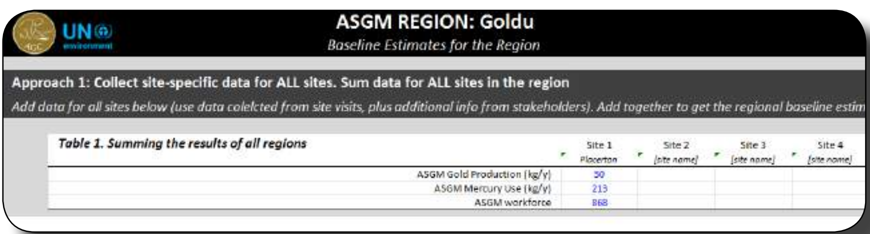
The second sheet of this workbook is called "**Region Calcs**" and contains tables for the two approaches outlined in Step 3.4: ("**All Sites**" and "**A Subset of Sites**").



Approach 1 – Sum the information from all sites:

If you surveyed ALL sites in the region and calculated site-specific estimates for every one of them,

Complete Table 1: For each site, copy and paste the final baseline values of workforce, gold production, and mercury use from the blue section of the **All Sites** sheet into **Table 1**. The table will sum all site-specific estimates to produce the regional estimates.



ASGM REGION: Goldu

Baseline Estimates for the Region

Approach 1: Collect site-specific data for ALL sites. Sum data for ALL sites in the region

Add data for all sites below (use data colelcted from site visits, plus additional info from stakeholders). Add together to get the regional baseline estim

Table 1. Summing the results of all regions	Site 1 Placerton	Site 2 [site name]	Site 3 [site name]	Site 4 [site name]
ASGM Gold Production (kg/y)	50			
ASGM Mercury Use (kg/y)	213			
ASGM workforce	868			

Approach 2 – Extrapolate the variables from selected sites:

If the region was too big to visit all sites and information is now needed for the sites that were missed,

Complete Table 2A:

Begin by entering all known information about the region in the regional data table - **Table 2A**. This information will come from the sector scoping phase (*e.g.*, national register of sluice numbers) and from field measurements (*e.g.*, a region-wide counts of extraction and processing units, typical ore grade from gold trader interview, ASGM workforce and/or gold production from official trade documents).

Placing all available regional information in one table will provide an accessible data summary and, although you established your extrapolation methods in the baseline research plan (Step 3), this regional summary will help identify additional methods if needed for cross-check.

Approach 2: Collect averages of common variables by visiting a subset of sites (previous tab - 'All Sites'). Fin

Add all known data for the region (immediately below). Add key averages of information collected at your subset of sites

Table 2A. Available information about the region. Add all known region data here.

		source	source
General			
	Ore Grade (g/T)		
	Gold Purity (%)		
	Total ASGM Workforce		
	Annual Gold Production (T/y)		
Extraction			
	total miner workforce		
	% of workforce miners		
	no. of mining sites - total		
	no. of mining sites - large		
	no. of mining sites - med		
	no. of mining sites - small		
	no. of extraction units		
Processing			
	processor workforce		
	% of workforce processors		
	no. of mining sites		
	No. of processing sites - total		
	No. of processing sites - large		
	No. of processing sites - med		
	No. of processing sites - small		
	no. of processing systems type 1		
	no. of processing systems type 2		
	no. of processing systems type 3		
	Hg:Au Ratio		

Use Table 2B as a guide for calculating baseline estimates for the region:

Couple the site-level key averages and baseline estimates with the regional information to extrapolate site data to regional estimates. Table 2B holds suggestions on how this extrapolation can be done. Check cell comments for a description of each calculation. This table of suggestions is a good place to start but is by no means comprehensive. You will likely find additional ways to extrapolate baseline estimates for the region. Draw on the regional data from Table 2A and the key regional averages from the All Sites tab to make these calculations. The following section provides three examples.

Table 2B. Extrapolation and Cross-check Exercises. Combine Region Data (Table 2A., directly above) and Site-based Av

View comments embedded in cells for calculation suggestions. These calculations are not the only options available. Regional estimated can be calculated i
country, the region, and the information that has been collected from ASGM sites, and the regional infomation available. Add to the table below as per met

	Regional Estimates *Goldu*	Comments
Region Data: Workforce | Site-based Data: Extraction Info		
Total Number of Miners		
Annual Gold Production (T)		
Annual Hg use (T)		
Region Data: Gold Production | Site-based Data: Extraction & Processing Info		
Total Gold production		
Total ASGM workforce		
Region Data: Number of Extraction Sites | Site-based Data: Extraction Info		
Number of large mining sites		
Number of medium mining sites		
Number of small mining sites		
Average miner workforce of large sites		
Average miner workforce of medium sites		
Average miner workforce of small sites		
Total Miner Workforce		
Total ASGM Workforce		
Annual Au Production		

Remember,

Extrapolation is invariably the most difficult and most crucial step of the ASGM estimate. Good, high confidence regional data must be used, as large errors can result when scaling up spatially by large factors. The best practice is to extrapolate in more than one way. Creativity is encouraged, as conditions and ASGM practices are different in every region.

Regional Data: Which Data are Best?

Many different types of regional information can be used in regional extrapolation, as long as the information is *(a) regional; (b) relevant to the local data collected; and (c) reliable.*

For example, you may be working in a region where you have visited a representative subset of sites and have derived statistics on the **average number of miners per open pit (20 miners/pit) and annual gold production per pit (3 kg Au/y/pit).**

A piece of regional data that is relevant to the local data collected might be the **number of pits in the region**.

Extrapolating Regional Gold Production Example #1 Number and gold production of pits:

local data: average annual gold production *for a pit* **(3 kg Au/y/pit)**
regional data: *number of pits* in the region **(40 pits)**

(average gold production for a pit) x (# of pits in the region)
= 3 kg Au/y per pit x 40 pits
= 120 kg Au/y in the region

Of course, the relevance of this data depends on whether all pits in the region are of similar size. If they are not of similar size, you may choose to break production down by pit size (e.g., small and large) and then count the number of pits of each size in the region (see facing page).

Extrapolating Regional Gold Production Example #2
Number, size, and gold production of pits:

Local data: average annual gold production f*or a pit of each size*
(2 kg Au/y/small pit, 4 kg Au/y/large pit)
Regional Data: *number of pits of each size* in the region
(30 small pits, 10 large pits)

(average gold production for small pit x # of small pits in the region) +
(average gold production for large pit x # of large pits in the region)
= (2 kg Au/y/small pit x 30 small pits) + (4 kg Au/y/large pit x 10 large pits)
= 100 kg Au/y in the region

If the region is small and accessible, the number and size of pits in the region might be estimated by driving around the region with a knowledgeable miner and counting the pits. This piece of information is *(a) regional, (b) relates to the data collected, and (c) reliable* because you have collected the information yourself and have feedback from a knowledgeable source. (You should still cross-check with the opinion of another expert or stakeholder for added confidence).

If the region is large and/or inaccessible, you might (a) find the number of pits in the region in a different way (*e.g.*, interviews with mining coordinators, community leaders, gold shops, government), or (b) find a different regional statistic, such as miner population:

Extrapolating Regional Gold Production Example #3
Number of miners and gold production per miner:

local data: average annual gold production per miner
(3 kg Au/y/pit) / (20 miners/pit) = 0.15 kg Au/y/miner
regional data: number of miners in the region
(800 miners)
(average gold production for a miner) x (# of miners in the region)
= 150 g Au/y/miner x 800 miners)
= 120 kg Au/y in the region

7.2. Three Examples of Extrapolating Regional Estimates of Mercury Use

In *Section 3.2* of this chapter, we learned how to develop site-level information using three types of approaches (extraction-, processing-, and income-based). In this section, we will extend these examples to extrapolate region-level estimates of mercury use, gold production, and workforce.

orange text = raw field data (from interview or measurement)
blue text = variable calculated by averaging site data
red text = regional estimate

7.2.1. Extrapolating Regional Baseline Estimates: Extraction-based Approach

Variables found by averaging data from all sites (site data: Section 6.2.2.):

- Average number of extraction workers per extraction unit (workers/unit)
- Average number of extraction workers on an ASGM site (workers/site)
- Average annual gold production per extraction unit (kg/y/unit)
- Average annual gold production per extraction worker (g/y/worker)
- Average annual gold production for an ASGM site (kg/y/site)

Data collected about the region:

- Number of active ASGM sites in the region
- Number of extraction units in the region
- Other

Regional estimates found by extrapolating to the region:

- **Number of ASGM extraction workers in the region (workers/region)**
- **Annual ASGM gold production in the region (kg/y/region)**
- **Annual ASGM mercury use in the region (kg/y/region)**

D**ata Collection in the Region and Extrapolation to Regional Estimates**:

1. Consult the ASGM Sector Scoping Report for the number of active ASGM sites in the region. If it is not found in the report, this data may be found in the records of national, regional, or community/district ministries or LSM concession registers. Interviewing community or mining leaders may also yield a specific or general estimate.

2. Cross-check this information by hiring a local miner to drive with you to count ASGM extraction sites and total and active extraction units.

3. Extrapolate from the average number of workers per site to the **total number of extraction workers in the region (workforce)** by multiplying the (total number of extraction workers on the ASGM site) x (number of ASGM sites per region).

4. Find **annual ASGM gold production in the region** using calculated site data with a known piece of information about the region. For example, the average annual gold production per extraction unit and the number of extraction units in the region or the average annual gold production per miner and the number of miners in the region.

5. Break down the **annual ASGM gold production in the region into the average percent of gold contributed by each type of processing.**

6. Determine the **annual ASGM mercury use in the region for each processing type (*e.g.,* annual mercury use by all sluices in region and annual mercury use by all WOA mills in the region)** by applying the known Hg:Au ratio for a processing type to its **annual ASGM gold production in the region**.

7. Determine the **annual ASGM mercury use in the region by summing the annual mercury use for all processing types (*e.g.,* annual mercury use by all sluices in region + annual mercury use by all WOA mills in the region).**

orange text = raw field data (from interview or measurement)
blue text = variable calculated by averaging site data
red text = regional estimate

7.2.2. Extrapolating Regional Baseline Estimates: Processing-based Approach

Variables found by averaging data from all sites (site data: Section 6.2.3.):

- Number of processing workers on the ASGM site (workers/site)
- Average gold produced per cycle for a processing unit (g/cycle/unit)
- Average gold produced annually for a processing unit (kg/y/unit)
- Gold produced annually on the ASGM site (kg/y/site)
- Mercury used per cycle for a processing unit (g/cycle/unit)
- Mercury used annually for a processing unit (kg/y/unit)
- Mercury used annually on the ASGM site (kg/y/site)
- Hg:Au ratio for each processing unit type

Data collected about the region:

- Number of ASGM sites with active processing in the region
- Number of active processing systems in the region
- Distribution of processing unit types and throughput or gold production for each, so that specific Hg:Au ratios may be applied
- Other (depends on the scenario in the region)

Regional estimates found by extrapolating to the region:

- **Annual ASGM gold production for the region (kg/y/region)**
- **Annual ASGM mercury use for the region (kg/y/region)**
- **Average Hg:Au ratio for each processing unit type**
- **Number of ASGM processing workers in the region (workers/region)**
- **Number of ASGM extraction workers in the region (workers/region)**

orange text = raw field data (from interview or measurement)
blue text = variable calculated by averaging site data
red text = regional estimate

<u>Data Collection in the Region and Extrapolation to Regional Estimates</u>:

1. Consult the ASGM Sector Scoping Report for the number of ASGM sites with active processing in the region and the number of active processing units in the region. If it is not found in the report, this data may be found in the records of national, regional, or community/district ministries or LSM concession registers. Interviewing community, site, or mining leaders may also yield a general estimate. It may be possible to obtain this information by hiring a local miner, driving around, and counting extraction sites and extraction units.

2. Use the number of workers per processing unit per shift, number of shifts per day, and number of active processing units in the region to calculate the **number of ASGM processing workers in the region (workforce).**.

3. Divide the total daily throughput on the site by the average daily ore production per extraction worker to derive the **number of ASGM extraction workers in the region**. (Note whether extraction workers also work as processing workers to decided whether to add these two workforce estimates).

4. Extrapolate **annual ASGM gold production in the region** using site data and a known piece of information about the region. For example, the annual gold production per processing unit and the number of processing units in the region or the annual gold production per processing worker and the number of processing workers in the region.

5. Break down the **annual ASGM gold production in the region into the average percent of gold contributed by each type of processing.**

6. Determine the **annual ASGM mercury use in the region for each processing type (*e.g.,* annual mercury use by all sluices in region and annual mercury use by all WOA mills in the region)** by applying the known Hg:Au ratio for a processing type to its **annual ASGM gold production in the region**.

7. Determine the **annual ASGM mercury use in the region by summing the annual mercury use for all processing types (*e.g.,* annual mercury use by all sluices in region + annual mercury use by all WOA mills in the region).**

7.2.3. Extrapolating Regional Baseline Estimates: Earnings-based Approach

Variables found by averaging data from all sites (site data: Section 6.2.4.):

- Annual gold production for the site (kg/y/site)
- Annual gold production per worker (g/y/worker)
- Annual mercury use for the site (kg/y/site)
- Annual earnings per extraction worker and processing worker (g/Au/y)
- Distribution of total revenue to extraction and processing workers (%)
- Hg:Au ratios for each processing method

Data collected about the region:

- ASGM workforce in the region
- Annual ASGM gold production in the region
- Other (depends on the scenario in the region)

Regional estimates found by extrapolating to the region:

- **Annual ASGM ore production in the region (T/y/region)**
- **Annual ASGM gold production in the region (kg/y/region)**
- **Annual ASGM mercury use in the region (kg/y/region)**
- **ASGM extraction and processing workforce**

Data Collection in the Region and Extrapolation to Regional Estimates:

1. Consult the National Level ASGM Sector Scoping Report or a previous estimating approach the team applied (*e.g.*, processing-based) to find the ASGM workforce in the region. For example, the Ministry of Mines may have provided an estimate of this statistic.
2. Couple the annual gold production per worker with the ASGM workforce in the region to extrapolate the **annual ASGM gold production in the region**.
3. Interview gold shops and gold buyers to cross-check the **annual gold production in the region**.
4. - OR - if you already have **annual ASGM gold production in the region,** extrapolate **workforce in the region** by breaking down **annual gold production in the region** by the proportion of total revenue distributed to extraction and processing workers and annual earnings of each.
5. Calculate **annual mercury use in the region** by applying the known Hg:Au ratio(s) to the **annual gold production in the region** (remember, the proportion of gold produced by each processing unit type and a Hg:Au ratio for each unit type must be known).

Step 8 – Triangulating Regional Estimates

This section will guide you to:

- Compile regional baseline estimates from as many sources as possible in a process called triangulation, to get a range of values;
- determine the likelihood that the estimate range is accurate based on how narrow or wide the range is.

Background reading:

- Chapter 1, 8.3: Cross-checking and Convergence (Triangulation), p. 82

Supporting tools used in this step:

- Data synthesis and analysis tools (Annex A3):
  ASGM_region.xlsx

Finding a good robust baseline estimate requires **triangulation**. Triangulation is the technique of comparing baseline estimates from different independent sources as a way of cross-checking the accuracy and validity of each of the several sources. Regional estimates of mercury use, gold production before applying the Hg:Au ratio, and workforce must be triangulated to increase confidence in the results. Regardless of the variable being triangulated, the goal is to compile as many estimates of the variable from as many different sources as possible. Compiling these estimates provides a range of that variable for the mining region. The narrower this range, the higher the likelihood that this production figure is accurate.

When triangulating regional estimates, a large range between the estimates indicates that one or many of the estimates are potentially incorrect. If this happens, you must determine whether the range is real or the result of an error in one or several of the estimates. Carry out the following steps to remedy the situation.

Step 1. Crosscheck through site knowledge gained in the field.

For example, a LSM industrial cyanidation centre may process some artisanally extracted ore in the region. If the throughput of LSM industrial cyanidation was not considered in a processing-based estimate, there will be an underestimation of the total ore extraction, gold production, and miner population. (There would be no effect on the regional estimate of mercury use, as no mercury is used in cyanidation). As another example, the extraction-based and processing-based estimates of mercury use may be slightly different. This may be because the processing units in this region are situated far from the extraction units and there is some disconnection between the two. For instance, the mines may be located upslope in mountainous terrain and the processing centres concentrated in a community at the foot of the mountains.

Step 2. Consider the quality of the data sources used in the estimate.

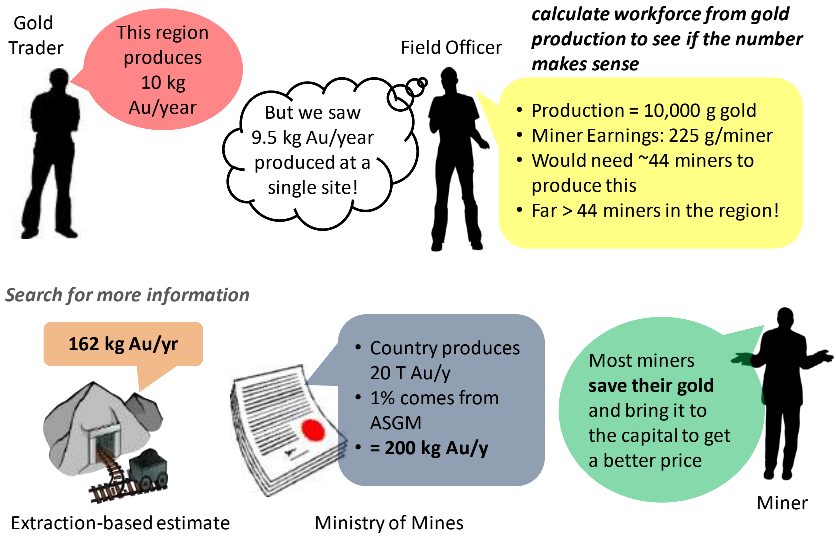
For example, one of the regional estimates may rely on a statistic of ASGM gold production reported in an official trade document. Since this statistic is commonly a very coarse estimate based on LSM data, it may be in the same order of magnitude but not an exact match to the results of more robust measurement approaches. The same applies for an earning-based estimate. Annual earnings and revenue distribution are difficult to find with accuracy due to secrecy and social politics and therefore this method is expected to be less accurate than the extraction and processing-based methods

Step 3. Crosscheck through knowledgeable stakeholders.

Show the numbers to various stakeholders (*e.g.*, government officials, local leaders, mining coordinators, gold shops). Favour consultation with those stakeholders who attended the baseline training, as they will be familiar with how the estimates have been derived. The stakeholders may quickly spot the statistic that is incorrect in your calculation. For example, your calculations may have assumed that the total gold transiting through the gold shops is equal to the total amount of gold produced in the region. However, the community leader you consult with mentions that many of the miners keep their gold due to extreme fluctuation in the local currency.

Step 4. Collect more data. Derive the estimate in a different way.

If you have used the extraction and income methods, try calculating the estimate using data from processing sites. See how the result compares to the other two.



Supporting Tool:

Open the workbook **ASGM_site.xlsx**. Ensure that all data from the field is compiled in the data entry sheets. Also ensure that the data has been filtered for quality in that poor-quality values are either highlighted and omitted from summary calculations.

In the **ASGM_region.xlsx** workbook, combine the field data and pre-existing data to calculate estimates of ASGM workforce, gold production, and mercury use at the region level in as many ways as possible.

If there is one extreme value, determine what caused this extreme value (missing data, misunderstanding of an interview question, a unique scenario). If there is no clear reason for this extreme value, it may be necessary to return to the site/ interviewee responsible for the outlier for additional information.

If the range is relatively wide with no singular extreme value, it may be necessary to visit more sites. Be sure to include the range in the final report, as this range is an indicator of certainty in the estimate.

Step 9 – Producing National Estimates

Now that the Field Team has produced high-quality regional estimates from several information sources and triangulated them to find a high-confidence estimate range, it is time to produce the national baseline estimates.

This section will guide you to:

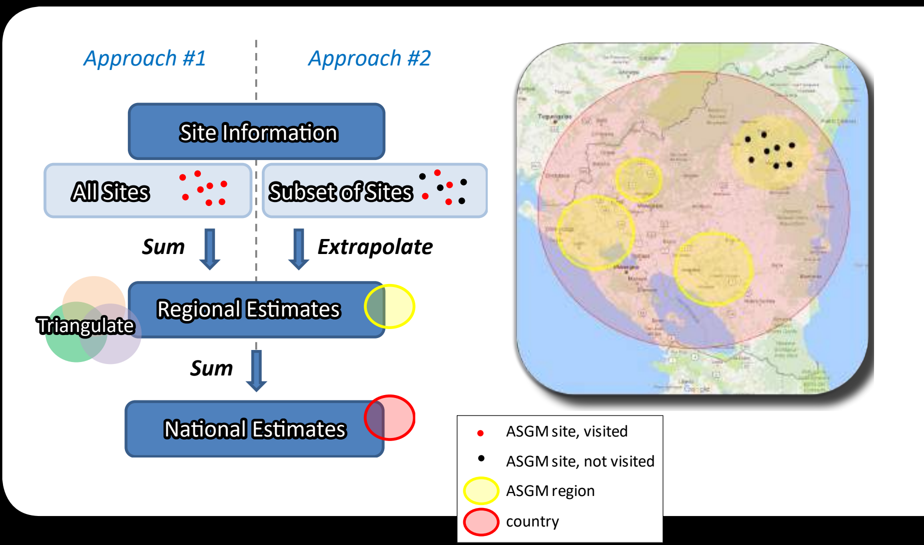
- Produce national ASGM baseline estimates of mercury use, gold production, and workforce from regional ASGM baseline estimates.

Background reading:

- Chapter 1, Section 8.4: Producing National Estimates, (p. 83)

Supporting tools used in this step:

- Data synthesis and analysis tools (Annex A3):
  ASGM_region.xlsx



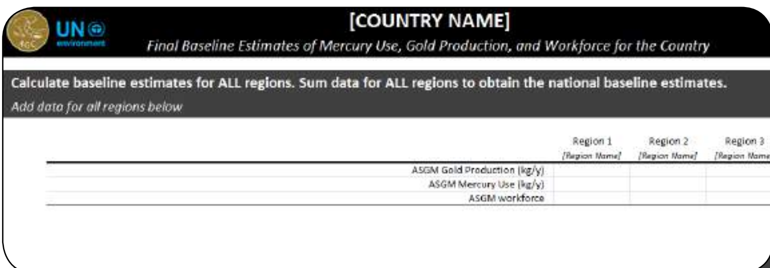
National estimates of the daily and annual total gold production and mercury use and the total ASGM workforce population are determined simply by summing the results of all regions within the country.

Supporting Tool:

Open the workbook **ASGM_country.xlsx** and save with the name of country, *e.g.*, **ASGM_country_Goldaguay.xlsx**. This workbook is used to compile the final baseline estimates of all the regions in the country. It is used to calculate the final national baseline estimates of mercury use, gold production, and workforce.

Note: All data entered by the researchers will appear in blue font. All information that is automatically calculated from the given data will appear in ***black font****. Also note that, upon initial download, all workbooks contain example data (in blue) as a guide for how the data might look.* ***Delete this data before starting your country analysis.***

Baseline estimates must be calculated for ALL regions before starting this step. Transfer the names of all regions to the **National Summary** table in the **ASGM_country.xlsx** workbook. Transfer the regional estimates of (1) workforce population; (2) gold production; and (3) mercury use for each region to their respective columns in the table. Sum each column to obtain the national estimates of ASGM workforce, gold production, and mercury use.



Step 10 – Final Report: The National ASGM Sector Baseline Report

Now that the regional estimates of ASGM workforce, gold production, and mercury use have been triangulated and summed into national estimates, the baseline estimates can be incorporated into a final report.

This section will guide you to:

- Synthesize information from the National-level Sector Scoping Report and baseline estimate research to produce the final report.

Background reading:

- Chapter 1, Section 2.3: What Information Needs to be Collected? (p. 38)
- Chapter 1, § 3. National-level ASGM Sector Scoping

Supporting tools used in this step:

- Information:
  ASGM_site(s).xlsx
  ASGM_region(s).xlsx
  ASGM_country.xlsx
  ASGM_scopingreport.docx

In a final report, compile (a) the contextual information from the ASGM Sector Scoping Report with (b) the key site-level information and regional and national baseline estimates you have produced. This report will be included in the NAP report. It will guide the development of mercury reduction strategies and provide a baseline to monitor the efficacy of these strategies.

Step 11 – Managing Spatial Data

An important aspect of ASGM data is its spatial component. Geospatial data or geographic information is the data or information that identifies the geographic location of the relevant ASGM data and features, such as:

- Locations of ASGM regions, communities, sites, extraction and processing units, cyanidation plants
- Mineralogy (geologic maps, type of deposit)
- Locations of various extraction, processing, and tailings management practices
- Estimates of mercury use, gold production, and workforce
- Locations of relevant stakeholders (*e.g.*, gold traders)
- Formal mining concessions and mining licenses (ASGM & LSM)
- Mercury entry points, trade points, and trade flows
- ASGM gold trade points, export points, and trade flows
- Locations of worst practices
- Locations of mining scars and poorly-managed mining wastes
- Locations of best (mercury-free) practices
- Population demographics of ASGM communities and workforce (men, women, youth, local, foreign)
- ASGM community resources (markets, places of worship, bank, insurance branch)
- Human health indicators
- Water bodies (streams, lakes, marsh, flood areas, ocean)
- Environmentally sensitive areas
- Elevation
- Roads, by type and accessibility
- Aerial imagery (satellite images, air photos, drone photos)

Spatial data are usually stored as coordinates and topology, and this data can be mapped. Maps are powerful communication tools that can assist policy makers and stakeholders to comprehend the scale and structure of ASGM activities. Maps of ASGM data allow critical activities, demographics, and resources to be considered in planning research, creating and implementing NAP strategies, and establishing policy. Furthermore, different types of spatial data can be mapped together to answer complex questions, such as:

Question: Where are the greatest health and environment impacts?
Spatial analysis: In which areas do ASGM practices that use mercury occur within a specified distance of communities, water bodies, environmentally sensitive areas, urban areas, *etc*.?

Question: Where are land disputes occurring and what is their extent?
Spatial analysis: Where do two land use categories overlap?

Question: Which regions should be targeted by the NAP as priority for mercury-reduction strategies?
Spatial Analysis: Where are the locations of worst practices? Where do these overlap with greatest populations of women and youth?

Question: Where is poor land-use management occurring and what is the extent.
Spatial Analysis: Examine a satellite image of the area. Identify mining scars, deforestation, tailings disposal, siltation, *etc*.

GIS software (*e.g.*, ArcGIS and the free, open-source platforms QGIS and Google Earth Professional) are useful tools for organizing, archiving, analysing, and displaying spatial data. Archiving spatial data with GIS software also standardizes the data, creating a structure for managing knowledge and streamlining sharing across departments and institutions.

Glossary of Terms

Acid test (for gold): A test for determining gold purity. The purer the gold, the stronger the acid required to dissolve it. Measured strengths of nitric acid are used to test for 14K purity and lower. Aqua regia, a mixture of one part nitric acid and three parts hydrochloric acid, is used to test for higher purity through the process of comparison and elimination.

Alluvial deposit: a loose deposit of sediments derived from the physical erosion of hard rocks and moved by wind and water to produce alluvial sediment, such as gravel and sand beds in rivers and old river sediments.

Amalgamation, concentrate: The process of separating metals from other minerals in a gravimetric concentrate of ore by adding mercury (which binds readily with the metals) after concentrating the ore by gravimetric means.
Amalgamation, whole-ore: The process of separating metals from other minerals in raw ore by adding mercury (which binds readily with the metals) to the raw, unconcentrated ore during the milling process.

Amalgam: A solid ball containing mercury, gold and other metals, formed during the process of *amalgamation*. The amalgam is typically about 50% mercury and 50% other metals, including gold.

Artisanal and small-scale gold mining (ASGM): The production of gold bearing mineral resources using largely manual and semi-mechanised techniques, by individuals, groups or communities.

ASGM baseline estimates: An inventory of estimated mercury used (lost to the environment), gold produced, and number of people working directly in a country's national ASGM sector (workforce). The **National Action Plan** must include a baseline estimate of mercury used. The latter two variables are critical to estimating mercury use and to developing effective NAP strategies.

ASGM baseline: a collection of important baseline information relating to the ASGM sector of a specific country. An ASGM baseline includes a **national overview of AGSM practices** and **national ASGM baseline estimates** of mercury use, gold prodcution and workforce.

ASGM sector overview: A detailed descriptive overview of the ASGM sector, including the spatial distribution of activities, the mining and processing techniques practiced, and the environmental and health concerns present. This is an important "big picture" understanding of the sector.

Baseline estimates: See **ASGM baseline estimates**.

Bullion: Gold (or other precious metal) which has been melted, refined (purified) to a variable degree, and cast into the form of a doré, ingot, coin, or bar. Typically used to trade on a market.

Chemical Leaching: The process of adding chemicals (most commonly cyanide – see *Cyanidation*) to milled ore and water to extract gold. The gold in the ore is converted to a water-soluble gold-cyanide complex in solution. Commonly, the gold-cyanide complex is absorbed into hard carbon and the carbon is then burned to yield the gold. Chemical leaching can be used to recover gold from primary ore or processed tailings.

Crushing: The process of reducing ore from large rocks down to a smaller but non-uniform size. Done manually with a hammer or mechanically with a crusher (*e.g.*, jaw crusher, hammer crusher).

Cyanidation: The process of adding cyanide to recover gold from primary ore or to recover (additional) gold from ore tailings. See **Chemical Leaching**. Cyanidation of mercury contaminated tailings is a banned worst practice according to the Minamata Convention, as the practice increases the mobility of mercury in the environment.

Doré: A semi-pure alloy of gold, which has been created at the mine site or gold trader shop by melting and casting. Usually traded on a market or transported to a gold shop or refinery for further purification. See **Bullion**.

Extraction unit: The location from which ore is extracted; Th most basic unit of mining activity on an ASGM site. Field data on ore extraction (*e.g.*, extraction rate) are measured per extraction unit and can then be scaled up to site- or regional-level estimates if the total number of units in the site or region is known. Examples of extraction units: number of miners in an open pit, a shaft, a tunnel, a group of surficial material miners, or other mining group.

Flotation: the process of separating small particles of various materials by treatment with chemicals in water to make some particles adhere to air bubbles and rise to the surface for removal while others remain in the water.
Grade (gold ore grade): The amount of gold contained within a sample of gold ore. Expressed in units of g/T as the weight of the gold (grams) present in the total weight of the ore (tonnes).

Grade, True: The true amount of gold contained within a sample of gold ore.
Grade, Recoverable: The amount of gold produced from a sample of gold ore by processing. (Changes depending on efficiency of processing method).

Grain-size control: The process of passing crushed or milled ore through a screen of a specific size to ensure a uniform grain size. Recovery is improved if the grain size matches the size of the gold deposits found in the ore.

Hard rock: a solid deposit of minerals that has not been broken down or transported. Examples of hard rock are granite or a gold-bearing quartz vein. Hard rock is also known as a primary ore deposit.

Large-scale mining (LSM): Produces gold on a much larger scale than ASGM, using fully mechanized extraction and processing techniques.

Mercury-to-gold ratio: A unitless value that represents the amount of mercury that is used to produce each gram of gold. Also denoted as Hg:Au ratio.
Mercury vaporisation: The process of applying heat to a mercury-metal amalgam, vaporising (evaporating) the mercury and leaving behind "sponge gold", a variable mixture of gold and other metals, including, at times, some residual mercury.

Milling: The process of reducing crushed ore to an even smaller, and more uniform size using a milling apparatus (*e.g.*, ball mill).

Minamata Convention on Mercury: A global agreement to protect human health and the environment from the adverse effects of mercury. The text of the Convention was agreed in January 2013, and was opened for signature in October 2013. The Convention came into effect on August 16, 2017.

National ASGM baseline estimates: Current estimate of mercury use (loss to the environment) by the ASGM sector at a national level and broken down into major mining regions. Estimates of gold production and workforce are also collected as (a) key variables in calculating mercury use and (b) key indicators of relative ASGM activity levels and identifiers of target regions for formalization and mercury reduction strategies (All three variables referred to as "*baseline estimates*" throughout the guidebook).

National Action Plan (NAP): A requirement under Article 7 of the Minamata Convention on Mercury for any Party where ASGM activity within its territory is deemed more than insignificant. A NAP is expected to cover baseline estimates of mercury use, reductions targets and strategies, and more holistic considerations such as education, health, and professionalizing the AGM sector. Annex C of the Convention specifies the required aspects of a NAP.

Ore (gold ore): Gold-bearing rock that has been removed from the ground for processing to extract gold.

Ore grade: see **Grade**.

Processing cycle: Relating to an ore processing system. the interval from the input of ore to the output of gold from that ore.

Processing unit: The most basic unit of ore processors on a processing site. Field data on ore production (*e.g.*, throughput, gold production, mercury use) are measured per processing unit and can then can be scaled up to site- or regional-level estimates if the total number of units in the site or region is known. Example of a processing unit: a system that includes a crusher, ball mill, and sluice.

Sedimentation: When tailings enter a body of water from an ore processing system (*e.g.*, sluice), contributing to an unnaturally high concentration of suspended sediments in the water. Sedimentation may have adverse environmental and health impacts.

Soft Rock: See **Alluvial deposit**.

Smelting: The process used to separate gold and other metals from the final ore concentrate (direct smelting), or to increase the purity of a portion of sponge gold. Concentrate or sponge is melted with the assistance of a flux, such as borax, which lowers the melting temperature of non-metallic minerals, thus enabling the liquids to fractionate by density. This liquid is then cast into a bullion or doré.

Tailings: The portion of ore discarded after processing to remove a portion of the gold (after gravimetric concentration and/or amalgamation and/or cyanidation). Depending on the processing technique applied, tailings may be contaminated with mercury and/or cyanide.

Triangulation: The technique of comparing estimates derived from independent sources as a way of determining a range of values for the estimate and cross-checking the accuracy and validity of each source.

Workforce: The total population that is directly dependent on the ASGM sector.

Workforce, primary: the total number of miners and processors in the ASGM sector.

Workforce, secondary: the total number of people involved in the secondary economy of an ASGM sector, including agricultural producers, merchants, traders, and service providers.

List of Acronyms

AGC: Artisanal Gold Council
ASGM: Artisanal and small-scale gold mining
Au: Gold
GEF: Global Environment Facility
GIS: Geographical Information System
Hg: Mercury
Hg:Au: Mercury-to-gold ratio
LBMA: London Bullion Market Association
LSM: Large scale mining
NAP: National Action Plan
NGO: Non-Governmental Organization
UAV: unmanned aerial vehicle
UN Environment: United Nations Environment Programme
UN Environment GMP: UN Environment Global Mercury Partnership
WHO: World Health Organisation
WOA: Whole ore amalgamation

Annex A. Supporting Tools

This annex provides a series of supporting tools for conducting ASGM baseline research. These tools include (A1) printable field forms; (A2) national sector scoping templates for data entry and reporting; (A3) Excel workbooks for data entry and analysis; and (A4) common equations and example calculations.

A1. Field Forms

<< ASGM_forms.xlsx >>

Purpose: These forms serve as question prompts and a means of checking that all pertinent data has been collected during the interview. Adapt these templates as required and as the team learns about on-the-ground realities during site visits.

Interviews

Community Interview
Gold Trader Interview
ASGM Site Interview

These forms guide interviews with community members/leaders, gold traders, miners, site leaders, owners, and other stakeholders to collect baseline data.

Observations

ASGM Site Observations

This form guides observations on a mining or processing unit to develop a rapid assessment of the general characteristics of the site. If there is a person in charge of the site (local authority, mining coordinator, *etc.*) he or she can be interviewed to assist in collecting the information on this sheet.

Physical Measurements

Mercury-Gold (Hg:Au) Ratio Form

This form is used to record data from physical measurements taken at an ASGM processing unit. Use one new form for each type of processing unit.

A2. Sector Scoping Templates

<< ASGM_scoping.xlsx >>

Purpose: This data entry template is for recording existing data on the ASGM sector in an organized way.

<< ASGM_scopingreport.docx >>

Purpose: This report template is for documenting the existing data on the ASGM sector in an organised report for archive and interagency sharing.

A3. Data Entry and Analysis (Data Workbooks)

<< ASGM_site.xlsx >>
<< ASGM_region.xlsx >>
<< ASGM_country.xlsx >>

Purpose: These workbooks can be opened in Microsoft Excel or Apache OpenOffice Calc (free and open-source). These workbooks are for entering data found in the field, coupling with regional data, and calculating baseline estimates, first for each ASGM site in a region, then for each ASGM region in the country, and then for the entire country.

Note: All data entered by the researchers will appear in blue font. All information that is automatically calculated from the given data will appear in **black font**. Also note that, upon initial download, all workbooks contain example data (in blue) as a guide for how the data might look. **Delete this data before starting your country analysis.**

A4. Equations and Example Calculations

<< ASGM_equations.pdf >>

Purpose: This document lists some common equations used to calcuate site-based variables and baselne estimates at the local and regional level.

Annex B. Training Module

This annex provides a package of materials designed to help train the baseline team and key stakeholders. This module includes (B1) a set of four PowerPoint Lectures; (B2) a suggested course syllabus; and (B3) a practice exercise handout.

All annex materials are available for download at:

- *http://web.unep.org/chemicalsandwaste/global-mercury-partnership/asgm/national-action-plans*
- *http://www.artisanalgold.org*

Acknowledgements and Permissions

The authors of this document are Jennifer O'Neill and Kevin Telmer of the Artisanal Gold Council (AGC). All photographs and images in the document except those specifically indicated are property of the Artisanal Gold Council and can not be used without permission.

We are thankful for the assistance and feedback provided by:

First and foremost, the numerous miners and others that we work with, many of whom are seen in the photographs of this publication.

And the following key contributors:

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Kenneth Davis, United Nations Environment Programme (UN Environment)
Malgorzata Stylo, United Nations Institute for Training and Research (UNITAR)
Susan Keane, Natural Resources Defence Council (NRDC)
Jesper Johnsson, COWI
Jerome Stucki, United Nations Industrial Development Organization (UNIDO)
Ludovic Bernaudat, United Nations Environment Programme (UN Environment)
Paul Cordy, Cordy Geosciences
Juha Ronkainen, United Nations Institute for Training and Research (UNITAR)
Dominique Bally Kpokro, L'ONG Jeune Volontaire pour l'Environnement Côte d'Ivoire (JVE)

The work was supported by United Nations Environment Programme (UN Environment) with funding from the Global Environment Facility (GEF). It was additionally supported in kind through the Artisanal Gold Council's various projects, past and present, which supplied most of the photographs in the document.

Estimating Mercury Use and Documenting Practices in Artisanal and Small-scale Gold Mining (ASGM)

An Artisanal Gold Council (AGC) document produced in conjunction with the UN Environment Global Mercury Partnership; 2017

This publication should be cited as follows:

O'Neill, J. D. and Telmer, K. (2017). *Estimating Mercury Use and Documenting Practices in Artisanal and Small-scale Gold Mining (ASGM).* Geneva, Switzerland: UN Environment. ISBN 978-0-9939459-8-4.

Available online:

http://web.unep.org/chemicalsandwaste/global-mercury-partnership/asgm/national-action-plans
and
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Helping artisanal and small-scale gold mining communities to derive the greatest environmental and social benefits from this development opportunity is absolutely possible. All that is needed is knowledge and understanding, innovation, finance, and will.

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ISBN 978-0-9939459-8-4