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# MERCURY TRADE AND USE FOR ARTISANAL AND SMALL-SCALE GOLD MINING IN SUB-SAHARAN AFRICA

FINAL REPORT



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# Mercury trade and use for artisanal and small-scale gold mining in Sub- Saharan Africa

FINAL REPORT

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# CONTENTS

Preface .....	5
Executive summary.....	7
Extended study summary.....	9
1 Introduction .....	19
1.1 Methodology.....	19
1.1.1 Databases and existing surveys and tools .....	19
1.1.2 Data collection in participating countries .....	20
1.1.3 Other collection of trade data.....	20
1.1.4 Questionnaire.....	20
1.1.5 Co-ordination with other trade analyses .....	20
1.1.6 Other literature .....	20
1.1.7 Uncertainties .....	20
1.2 Countries addressed by the study .....	21
2 Mercury trade and value chain .....	22
2.1 International trade of mercury and mercury-added products.....	22
2.1.1 Comtrade registered import and export of liquid mercury .....	22
2.1.2 Origin of mercury imported to Sub-Saharan Africa.....	29
2.1.3 Former export of mercury from the EU to Sub-Saharan Africa .....	36
2.1.4 Trade statistics for mercury compounds, amalgams and mercury added products .....	38
2.2 Price of mercury through the value chain.....	39
2.2.1 International trade.....	39
2.2.2 Local and sub-regional trade .....	44
2.3 Actors in the mercury supply chain .....	49
2.3.1 Link between mercury value chain an value chain for gold.....	54
2.4 Trade routes.....	56

2.5	Mercury sources in Sub-Saharan Africa .....	60
2.6	Overall mercury value chain .....	62
3	Consumption of mercury in Sub-Saharan Africa .....	64
3.1	Mercury use in ASGM and gold production .....	64
3.1.1	Production, import and export of gold.....	77
3.2	Use of mercury for other applications in Sub-Saharan Africa.....	78
4	Regulation of mercury trade and use in ASGM.....	81
4.1.1	License systems .....	81
4.1.2	Systems in participating countries .....	81
4.1.3	Overview of legal status.....	83
5	Environmental and health perspectives .....	86
5.1	Human exposure and health effects .....	86
5.1.1	Significance of mercury exposure in ASGM communities.....	86
5.1.2	Mercury health effects .....	86
5.1.3	Demonstrated mercury health effects in ASGM communities.....	87
5.1.4	Overall conclusion .....	88
5.2	Environmental effects and release sources .....	88
5.2.1	Environmental exposure and effects of mercury .....	88
5.2.2	Emissions to the atmosphere in Sub-Saharan Africa.....	89
5.2.3	Releases to the aquatic environments and soil .....	89
6	Abbreviations and acronyms .....	91
7	References.....	92
	Appendix 1: Mercury contaminated sites.....	95
	Appendix 2: Production of gold in the countries.....	96
	Appendix 3: Trade data for mercury added products and mercury compounds.....	103
	Appendix 4: Import of amalgams.....	110
	Appendix 5 Mercury trade data for other selected countries.....	112
	Appendix 6: List of miners' organizations .....	117
	Appendix 7: Questionnaire sent to the countries .....	118



## Preface

The present report is one of the main outputs of the World Bank project "Development of mercury trade diagnostic for Sub-Saharan Africa". The project builds on the current efforts of the World Bank Group, Environmental & Natural Resources in Sub-Saharan Africa, focused on chemicals and wastes. It specifically contributes through the development of a sub-regional trade diagnostic of mercury in Sub-Saharan Africa. In the context of this project, particular attention has been given to the domestic trade of mercury surrounding artisanal and small-scale gold mining – the largest mercury use and demand activity in the region and globally, of which so far little is yet known.

Besides this report, country reports for eight participating countries are included in a separate report. The participating countries are Burkina Faso, Côte d'Ivoire, DR Congo, Ghana, Senegal, Tanzania, Uganda and Zimbabwe. The separate report also includes a description and evaluation of a developed methodology and tool for site investigations of mercury use at artisanal and small-scale mining (ASGM) sites, and for development of country baseline inventories of mercury use for ASGM.

**Working group** - The project is implemented by COWI A/S Denmark and COWI Tanzania in cooperation with the following individuals and organizations:

- › groundWork South Africa (input on regional trade and questionnaires)
- › Alliance for Responsible Mining (local consultant in Senegal, Baptiste Hyacinthe Coué)
- › Noël Thiombiano (local consultant in Burkina Faso, affiliated with the Centre for Studies, Documentation and Research in Economics and Social Sciences, University of Ouagadougou)
- › Peter Appel (workshop and field training, affiliated with Geological Survey of Denmark and Greenland)
- › Sara Geenen (coordinator of activities in DR Congo, affiliated with CEGEMI (Expertise Centre on Mining Governance at Université Catholique de Bukavu, DR Congo) and Institute of Development Policy and Management (IOB) at the University of Antwerp, Belgium)
- › Bossissi Nkuba (local consultant in DR Congo, affiliated with Université Catholique de Bukavu)
- › Rogers Nunurai Murinda (local consultant in Zimbabwe, affiliated with Geo-Global Environmental Solutions)
- › Paul Yankson (Local consultant in Ghana, affiliated with University of Ghana)
- › Dominique Bally Kpokro (local consultant in Côte d'Ivoire, affiliated with World Alliance for Mercury-Free Dentistry)

- › Stephen Turyahikayo (local consultant in Uganda, affiliated with earthbeat foundation)

**Steering group** - The project has been followed by a steering group with the following participants:

- › Sanjay Srivastava, Ahmed Fall, Ruma Tavorath and Svetlana Khvostova, World Bank
- › Carsten Lassen, COWI A/S (Project Director) and Jesper Bosse Jønsson, COWI Tanzania (Team Leader)

**Country contact points** - The activities in the eight participating countries have been coordinated by the following country contact point:

- › Burkina Faso: Desire Yameogo Nonguema, Ministry of Environment and Sustainable Development

- › Côte d'Ivoire: Kouame Georges Kouadio, Ministry of Environment and Sustainable Development

- › DR Congo: Jean-Claude Emene Elenga, Ministry of Environment

- › Ghana: Sam Adu-Kumi, Environmental Protection Agency

- › Senegal: Aïta Sarr Seck, Ministry of Environment and Sustainable Development

- › Tanzania: Magdalena John Mtenga, Vice President's Office

- › Uganda: Christine Akello, National Environment Management Authority

- › Zimbabwe: Petronella Rumbidzai Shoko, Environmental Management Agency



## Executive summary

The mercury use and trade patterns in Sub-Saharan Africa have so far been difficult to assess by traditional statistics-based methods. This study aims at improving the understanding of mercury's role in the region through detailed investigation of import and export data in combination with field investigations in eight countries, literature study and a questionnaire survey sent to all countries in the region.

Artisanal and small-scale mining, ASGM, represents about 80% of the total mercury demand (or consumption as it is termed in this study) in the region, with most of the remainder being present in dental amalgam and imported mercury-added products.

ASGM was the main focus of the performed analysis, and being a largely informal activity, it can only be assessed with substantial uncertainty. A re-evaluated estimate of total mercury demand for ASGM in the region is 205 – 496 metric tons (t) per year. This estimate is partly based on previous work, partly on new information collected and analyzed for this study. The total number of miners involved in ASGM in Sub-Saharan Africa is estimated at 5-7 million; of these, the majority uses mercury.

While mercury may be traded legally in most countries in the region, most of the mercury trade between countries in the region is informal, unregistered and clandestine, most likely due to its links to illegal gold trade, cumbersome import procedures, and existing regulation of mercury usage in some countries. This is a major challenge in trade assessment work and will likely be so in future attempts to register and regulate the trade.

The analysis reveals the existence of three major hubs for mercury trade in the Sub-Saharan region: Togo, Kenya, and South Africa. In addition, Sudan is the largest importer in the region, but also a major user (export from Sudan to other countries in the region is still an area that needs further research). As there is very limited (if any) mercury production in the region (recycled and possibly by-products), close to 100% of the metal mercury demand is imported, and primarily through these four trade entries.

In-country data collection indicates that from the three trade hubs, most of the mercury is exported to other countries in the region in small amounts, typically from a few kilograms to a few "flasks" (standard containers of 34.5 kg mercury). This mercury is smuggled across porous borders in cars, trucks, busses, on bikes, motorbikes, etc. There are only a few known examples of legally reported larger quantity in-region exports, in these cases from South Africa to Zimbabwe, and they only represent a minor fraction of the estimated mercury demand in Zimbabwe.

Mercury prices on the world market have fluctuated significantly in recent years. The available information demonstrates that world market prices increased steeply from 2010 to 2012 and peaked in 2012-2013 at prices of USD 2,500 - 3,500 per flask of 34.5 kg. In recent years, the prices have decreased to USD 1,500 - 2000/flask in 2015 and USD 1,000-1,200/flask in 2016. Up to about 2012, a certain correlation was observed between gold price developments and the mercury price. However, this correlation is not seen since 2012,

and prices seem to be affected more by other factors, such as build-up and sell-out of commercial stocks, and new primary mining in Mexico and possibly Indonesia. The general pattern in 2016 is that mercury seems to be readily available in the ASGM areas, but at some sites miners are reported to sometimes accumulate small stocks to avoid shortages and associated price increases.

The regional mercury price patterns were also investigated in the countries participating in the project. As could be expected, the prices paid by the actual miners in the mining areas were typically 2-3 times and sometimes up to 10 times higher than the prices paid when purchasing directly from importers. The smaller quantities traded in the mining areas, the higher were the price. An example from the Kenya-based trade route showed prices at the mining sites around USD 100/kg for flasks of 34.5 kg up to about USD 250/kg for 50-60 g caps, and higher in times of shortage. The mercury supply chain typically has three to four steps, and the mercury is traded in closed supply chains, often linked to the clandestine gold trade, where personal introduction is typically the only way to get access.

The major reported exporters of mercury to Sub-Saharan Africa in 2014-2015 were China Hong Kong SAR (often reported as "China" by importing countries), Singapore, Switzerland, Turkey, India, Mexico, United Arab Emirates, and Ukraine. Based on world trade patterns, mercury ending up in Sub-Saharan Africa via official import seems to originate to a large extent from three to four sources: primary mining in Mexico, as a by-product mercury from zinc smelting in Japan and from recycled chlor-alkali plant mercury from Switzerland. China is the largest primary mercury producer globally (as well as the major consumer). China does not report any mercury export to official trade statistics (the UN Comtrade database), but a substance flow analysis of mercury in China for 2011 indicated that more than 100 t/year was exported.

The timing of the study was ahead of the ASGM National Action Plans (NAPs) development work in the participating countries. As a result, countries did not

have sufficient resources to participate and provide data to the study. Additional field study and inclusion of NAP data, when available, would reduce uncertainties in the quantitative assessment.

Controlling the mercury trade in the region may likely be a major challenge. Global efforts are therefore crucial for controlling the in-flow of mercury to the region, and it is imperative that a truly global implementation of the Minamata Convention is promoted, supported and enforced.

A close cooperation between the current mercury entry countries in the region (e.g. South Africa, Togo and Kenya) and the mercury using countries could play an important role in controlling the trade as well. A key challenge could be to promote and facilitate more transparency in the trade of gold from ASGM. Sudan and Ethiopia are reported to have had some success in this respect, and they could be studied further to derive any possible lessons learned.

The use of mercury-saving and release-reducing retorts and fume hoods is uncommon in the countries investigated. There are structural and practical challenges hampering a wider application of these techniques, and innovative, massive and consistent initiatives are needed for promoting their use, if reductions of emissions from the sector are to be achieved.

A number of important lessons were attained pertaining to guidance for data collection and systems developed to facilitate such collection in the ASGM field. It is recommended to engage in further development of such guidance and data handling systems.

Developing national inventories for the ASGM sector is quite complex, and substantial training and support of government staff and their field research assistants is needed.

This report was developed as part of the World Bank project "Development of mercury trade diagnostic for Sub-Saharan Africa". For a more detailed, yet aggregated presentation, see the extended summary and discussion in next chapter.





## Extended summary and discussion

The present report is the main output of the World Bank project "Development of mercury trade diagnostic for Sub-Saharan Africa".

### Methodology

In order to prepare a mercury trade diagnostic, published data for all of the approximately 50 countries in Sub-Saharan Africa have been collected from the UN Comtrade database, US Geological Survey Minerals Yearbook, Global Mercury Assessment and other data sources. The data retrieval includes data on liquid mercury trade as well as trade in gold, mercury amalgams, mercury compounds and mercury added products. Detailed assessment of the reported mercury trade, as reported by both importing country and the exporting partner countries, has been carried out for all countries. The publicly available trade data have been combined with information on informal trade and the mercury value chains in eight countries participating in the project: Burkina Faso, Côte d'Ivoire, DR Congo, Ghana, Senegal, Tanzania, Uganda, and Zimbabwe.

Furthermore, the trade data have been combined with information on the use of mercury for ASGM and other purposes in Sub-Saharan Africa in order to establish an overview of the actual mercury flows. Estimates for the use of mercury in ASGM have been obtained from the most recent Global Mercury Assessment report and updated and supplemented here, to the extent possible, with newer data for the major ASGM countries. On a regional basis, the total in-flow of mercury to the region is quite well known, and taking into consideration the estimated consumption for ASGM and other mercury

uses per country, a rough distribution of the imported mercury on individual countries has been made. The only major unknown is if unregistered mercury supply is substantial from countries that do not report to UN Comtrade.

### Mercury trade and mercury consumption for ASGM

The total official import to the countries in Sub-Saharan Africa in the period 2010 to 2015 ranged between 120 and 250 t/year as shown in Figure 0.1. During the same period, the total export to the countries, as registered by the partner (exporting) countries, was slightly lower with an average for 2010-2014 of 133 t/year as compared to the average of registered import of 174 t/year. The average net import (where export from the countries is subtracted) was 171 t/year, showing that the registered trade between the countries in the region was no more than 3 t/year (the actual trade is much greater than that registered, as described below). Data for 2015 are included in the figure, but the 2015 export data likely remain incomplete for some countries. The data for import has for some countries been revised as follows: in the case that no import is registered for some years (but registered for other years), the registered export to the country is used as a best estimate. As an example, Kenya did not register any import in 2011, 2012, 2014 and 2015 and the total registered import to Kenya for the period of 2010 - 2015 was 40 tonnes. During the same period, partner countries outside the region registered exports to Kenya of 127 tonnes. Actual imports well above 40 tonnes are supported by the collected field data indicating that a major

portion of the mercury used for ASGM in DR Congo, Uganda, and Northern Tanzania is informally imported from Kenya.

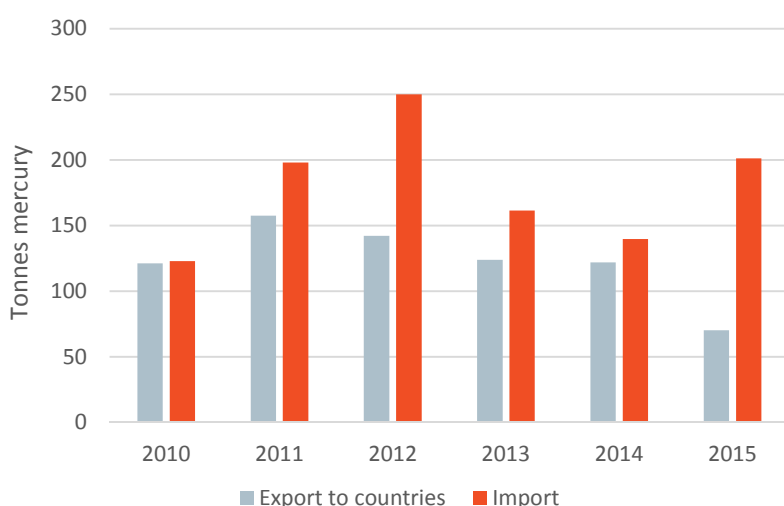
When the import and export are compared in detail, more profound differences appear; these can partly be explained by the fact that the importing and exporting countries register the same shipments differently. However, the differences may also indicate that either imports or exports are not registered properly. The study has assessed whether import of mercury under other commodity numbers, e.g. as amalgam or mercury compounds, could explain some of the differences, but no conclusive patterns can be seen (e.g. that missing reporting for liquid mercury is linked to reporting for other commodities).

Data for export of mercury from the EU during 2005-2011, before the EU export ban came into force in 2012, shows a total registered export from the EU to Sub-Saharan Africa (as registered to Eurostat by the EU Member States) and a total registered import to countries in Sub-Saharan Africa of 279 tonnes (as registered by the countries in the region). These data, as well as the new dataset for 2010-2015, do not indicate that import to the countries in Sub-Saharan Africa is systematically registered too low. There appears to be no reason why the major global export countries (as further described below), where export of mercury is fully legal, should not register the export to countries in

Sub-Saharan Africa. China does not register export of mercury to any country, but during 2010-2015 a total import of 163 tonnes from China was registered by the countries in Sub-Saharan Africa. This observation may be partially explained by using China, as opposed to China Hong Kong SAR, as country of origin (the latter reports export to Sub-Saharan Africa). However, this does not explain all of the registered import, and (un-registered) import from China may explain why the registered import exceeds the registered export to the region.

A comparison with the estimated mercury consumption for ASGM in the region indicates that the registered import to the region is lower than the actual import; in particular regarding West Africa, as further described below. The total import to Sub-Saharan Africa is roughly estimated at 200-400 t/year on this basis, reflecting the associated uncertainties.

The official statistics provide limited information about the trade between the countries in Sub-Saharan Africa, apart from some reported trade between South Africa and countries in southern Africa, primarily Zimbabwe. The information collected in the field confirms that the ASGM "sector" is characterized by informal trade of mercury. Even though the use of mercury for ASGM in many of the countries is not banned, some restrictions on the use of mercury for ASGM and on its shipment/trade makes mercury a controversial commodity.



**Figure 0.1**

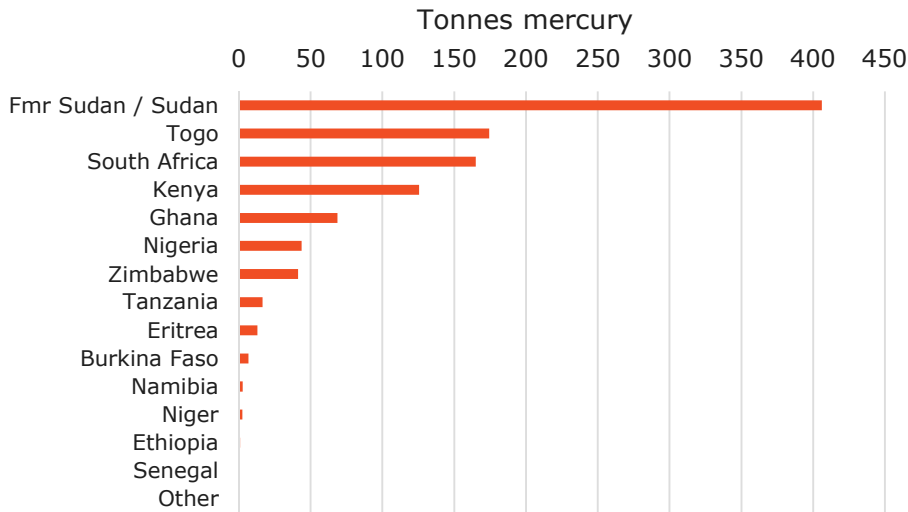
*Total registered import to countries in Sub-Saharan Africa as registered by the countries and export to the countries as registered by partner countries (Source: UN Comtrade). For some countries with missing import data some years, data for export to the countries are used, please see Table 2.2 for details. Note that data for 2015 may still be incomplete.*

Even though the registered quantities may be too low, the trade data clearly indicate the major import countries in the region. The largest importer is Sudan in the region, and the reported import of mercury is in line with

the expected use for ASGM. In Togo, South Africa and Kenya imports exceed the estimated consumption, and these countries serve as trading hubs for mercury in the regions. Ghana, Nigeria, Zimbabwe and Tanzania all

have a registered import, but the expected consumption for ASGM exceeds the imports, and field investigations show that the gap is filled by mercury informally imported from the three countries which serve as mercury trade hubs. Large imports of mercury were registered to Ethiopia in 2013 and 2014, but no countries have reported export to Ethiopia. Furthermore, field investiga-

tions have not identified any mercury reported to come out from Ethiopia, while it is reported that the mercury consumption for ASGM in Ethiopia is small; also, the reported value of the imported mercury is much too low. For this reason it is considered most likely that the registered import to Ethiopia is inaccurate; an assumption that could be investigated in any follow-up work.



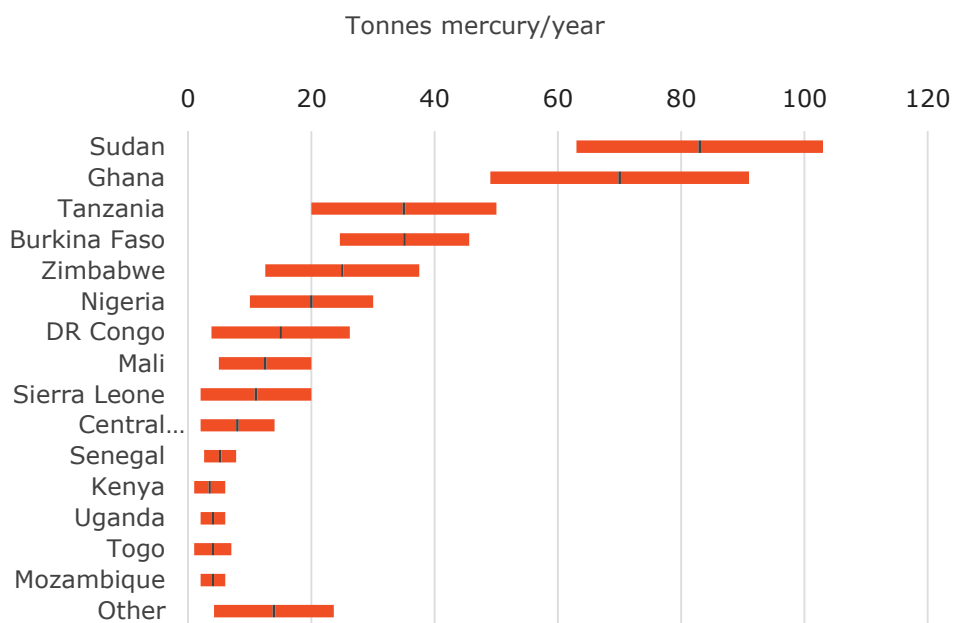
**Figure 0.2**  
Total registered import to countries in Sub-Saharan Africa of liquid mercury (HS code 28 05 40) for the period 2010-2015. For some countries with missing import data, data for export to the same countries are used, please see Table 2.2 for details.

The total consumption of mercury for ASGM in Sub-Saharan Africa in 2010 was estimated at a total of 334 t/year (range 189-472 t/year, calculated by simple addition) in the Global Mercury Assessment 2013. The use in ASGM was estimated to account for about 90% of the intentional mercury use in the region, and for more than 95% of the use of liquid mercury.

The total estimate for the eight countries participating in this study is 196 t/year, corresponding to 59% of the estimated total for the region. Among the top five mercury using countries, four participated in this project: Ghana, Tanzania, Burkina Faso and Zimbabwe.

As part of the project, the consumption for ASGM in the countries has been re-evaluated. According to the re-evaluated data, Sudan is the major ASGM country in the region. The quantities of gold extracted by ASGM in Sudan has increased steeply during the last five years.

The total mercury consumption for ASGM in 2015 is estimated to be within the range of 205 to 496 t/year. The total number of miners involved in ASGM in the region is estimated at 5-7 million; of these, the majority uses mercury.



**Figure 0.3**  
Estimated mercury consumption for ASGM in 2015 by country

### Trade routes within the region

As mentioned above, the registered imports to Kenya, South Africa and Togo significantly exceed the expected consumption of mercury within the countries. Data from the field confirms that the mercury trade routes begin in these hubs of mercury import to the region. The overall trade flow is illustrated in Figure 0.5.

**Eastern and Southern Africa** - From South Africa, the mercury is transported north to the ASGM fields in Zimbabwe, Mozambique and Southern Tanzania and possibly further to DR Congo. The total import corresponds quite well with the expected consumption in this sub-region. From Kenya, mercury is transported to ASGM fields in Kenya, Northern Tanzania, Uganda, Burundi, and DR Congo. The registered import to the countries, when using data for export to Kenya as reported by partner countries, is somewhat lower than the expected consumption. The missing data on import to Kenya indicates that the import to this country may be even higher than the registered export to the country.

**Western Africa** - In Western Africa, the major trade route is from the free port in Lomé in Togo to the neighboring countries, primarily Ghana and Burkina Faso. Significant quantities of mercury are also imported directly to Ghana and Nigeria. Mercury used in Senegal is traded via Mali and Guinea, and the available information indicates that this mercury is transported via Burkina Faso from Ghana and Togo and that persons originating from Burkina Faso are responsible for

much of the illegal mercury trade (and illegal gold trade) in this sub-region. The total registered import to Western Africa is significantly less than the estimated consumption for ASGM. One informant has informed on mercury illegally imported to Ghana hidden in ships and unloaded from the ships together with the ships' waste. If the information is correct, it would indicate a link to illegal activities in the exporting countries.

**Sudan** - Sudan seems to be a market on its own where the official import quite well corresponds to the estimated consumption in the country. It is uncertain to what extent mercury imported to the country is transported further to countries in the central part of the continent such as Chad and Central African Republic. These countries seem to have an increasing mercury-based gold production. According to available information, ASGM in Ethiopia and South Sudan is mainly based on mercury-free methods. This is well in accordance with the official statistics, but field activities have not been undertaken in these countries as part of this project, and consequently information on the informal trade in these countries is not available.

**Trade within the region** - Apart from relatively minor registered exports from South Africa to Zimbabwe and other neighboring countries, the trade between the countries in Sub-Saharan Africa is informal. The mercury is smuggled across porous borders in cars, trucks,

buses, bikes, motorbikes etc. in quantities of a few kg to some flasks<sup>1</sup>. From two of the countries it is reported that the crossing of borders is made by persons specialized in illegal cross-border trade or that traders pay bus drivers to bring the mercury across the borders. Bribery of customs officials has been mentioned by several informants in more of the countries.

The only identified example of above-board trade of larger quantities within the region is export of mercury from South Africa to the only registered importer in Zimbabwe, but this import still only accounts for a small portion of the total import to Zimbabwe.

### Mercury prices through the supply chain

Mercury prices on the world market have fluctuated significantly in recent years. The available information demonstrates that world market prices increased steeply from 2010 to 2012 and peaked in 2012-2013 at prices of USD 2,500 - 3,500 per flask of 34.5 kg. In recent years the prices have decreased and in 2015 they were at levels of USD 1,500 - 2000/flask; these prices have decreased further in 2016 to a level of about USD 1,000-1,200/flask. Export data from partner countries to the major import countries, Togo, South Africa and Sudan, show a consistent trend in the prices of mercury exported to the three countries. The value of registered import to Togo and Sudan, as registered by the countries, is however much lower, indicating that for various reasons the importers indicate that the value of the imported mercury is far below the actual value, perhaps to evade import tax.

Official trade data from major Asian import and export countries indicate that mercury at prices significantly below USD 1,000/flask is available on the world market. Information obtained from six importers of mercury to South Africa indicated highly significant differences in price. For this study, the importers have reported prices ranging from USD 450/flask to USD 3,500/flask when the mercury is sold in entire flasks within South Africa. The decreases in price on the world market also influence the prices in the ASGM areas; for example, it is reported that the prices in mining sites in Uganda have been reduced by half in recent years. Even larger decreases are reported from Zimbabwe. August 2016 it

was possible to buy mercury in shops in Nairobi, Kenya, in 1-kg bottles at a price corresponding to USD 1,200/flask indicating that the mercury may be imported at significantly lower prices. In September 2016 an informant from Zimbabwe stated that mercury could be purchased by kilo in South Africa at prices corresponding to USD 1500/flask.

As for other commodities, the price of the mercury increases through the value chain and is dependent on the quantities purchased. The figure below shows approximate prices reported for mercury imported to Kenya and smuggled to mining areas in Northern Tanzania. Similar prices are reported from the other countries. It is common that small traders buy mercury in 34.5 kg flasks or 1-2 kg bottles in Kenya and sell it in the mining areas at a price of two to three times the original purchase price.

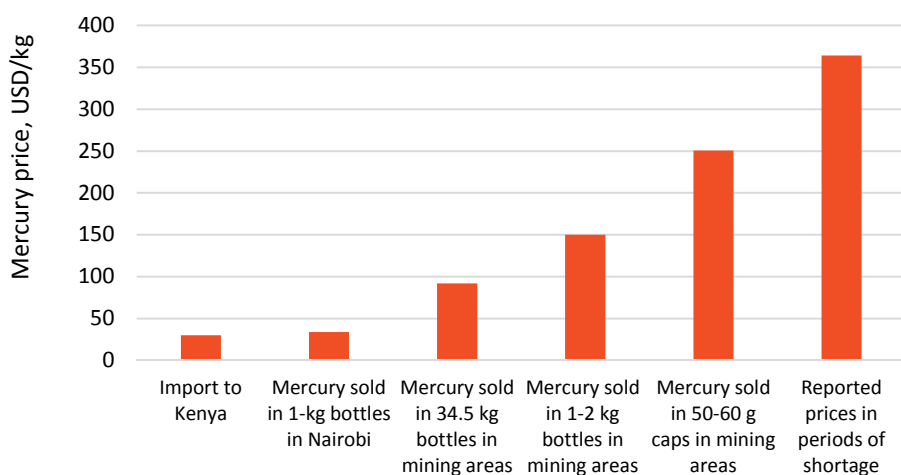
In Senegal, it is reported that mercury for medical purposes is sold at significantly higher prices than mercury for ASGM, probably because the mercury is of higher purity. However, it has not been possible to obtain consistent data across the region demonstrating differences in prices as a consequence of different qualities of mercury.

### Total revenue

With an estimated mercury trade of 200-400 tonnes and a revenue through the value chain within the region of approximately USD 150-200/kg, the total revenue from the mercury trade in Sub-Saharan Africa in 2015 can be estimated at USD 30-80 million. Considering a typical income of USD 3,000/year in these countries, this range corresponds to the income of 10,000 - 27,000 people at this level. The calculation is used to illustrate the number of people which could be involved in the trade. The majority of the involved would be in the bottom of the supply chain pyramid, and these people are typically also involved in gold trade. Telmer (2016) estimates that worldwide there are approximately 50,000 small gold shops serving artisanal and small scale gold miners. The estimate is based on information from UNIDO's Global Mercury Project that each gold shop serves 200 miners. If this assumption is applied on the estimated number of miners in Sub-Africa Africa of 5-7 million, the number of small local gold shops would be some 35,000-45,000.

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<sup>1</sup> A "flask" of mercury contains 34.5 kg of mercury (a well defined trade unit and also the measure of the physical containers often used).



**Figure 0.4**

*Development in price of mercury through the value chain in Kenya and mining areas in Northern Tanzania in 2016. The average price of mercury exported to Kenya in 2015 was USD 54/kg, but based on data on the world market price trend from 2015 to 2016, it is estimated that the average price in the first half of 2016 likely was about USD 30/kg*

## Actors in the value chain

The value chain of mercury has many different actors and the types of suppliers may be different from site to site and between countries. The overall pattern is that mercury is imported from countries outside the region by trading companies, either specialized in trading of metals or mining equipment, or general trading with main interests in agricultural commodities. From the importers, the mercury is mainly traded through two separate types of value chains: a value chain intertwined with the value chain for gold, and a value chain of companies and individuals specialized in mercury trading. It is reported from many countries that it is very difficult to get information on the value chains, which are operated in clandestine ways; as well, the mercury is traded in closed circles, where personnel introductions are often the only way to get access.

As mentioned, mercury is a "hidden" commodity in all countries, and the small traders avoid applying for licenses and registering import from other countries in the region, probably to evade taxes. In the context of study methodology, collecting economically sensitive data in an informal and often crime affected sector is associated with substantial personal safety risks, so there are limits to how far one can go on this path.

Besides these two main value chains, mercury can be purchased in some pharmacies and mining equipment shops in the mining areas. It is furthermore reported that some mercury originating in laboratories, dental clinics and hospitals may end up in ASGM. The data collected in the field in the eight participating countries indicate, however, that by far the majority of the mercury used at the ASGM sites is purchased via the two

main value chains mentioned above. The total quantities of mercury used for dental amalgam and in mercury-added products is small as compared to its consumption in ASGM, indicating that mercury disseminated from the health sector to the ASGM sector is limited.

The final buyers of the mercury are either the artisanal miners themselves, or the license owners or financiers who supply the mercury to the miners. Small-scale miners and claim owners also sell mercury to artisanal miners to some extent, and thereby add an additional link to the value chains.

The general pattern is that mercury is readily available in the mining areas but from some sites it is reported that the miners sometimes accumulate small mercury stocks for use in periods of supply shortages, to avoid higher mercury prices.

Recovery of mercury by use of retorts and fume hoods is uncommon and no examples of sale of recovered mercury from retorts and fume hoods, or from recovery of mercury-containing tailings, have been identified.

## Origin of mercury imported to Sub-Saharan Africa

Mercury is imported to the region from many countries. The major exporters to Sub-Saharan Africa in 2014-2015, where the export has been confirmed by both import data for the importing countries and export data from partner countries, are China Hong Kong SAR (often indicated as China by importing countries), Singapore, Switzerland, Turkey, India, Mexico, United Arab Emirates, and Ukraine. Historically, the majority of mercury was exported from the EU, but after the EU export

ban came into force, other countries have developed into major exporters. Globally, the major export countries according to official statistics are Japan, India, Singapore, China Hong Kong SAR, Mexico and Switzerland. Singapore and China Hong Kong SAR, and to a minor extent United Arab Emirates, have developed into major trading hubs for mercury, though they do not produce mercury themselves. Imports to these countries originate from Japan, Switzerland and Indonesia, whereas no export from China (outside China Hong Kong SAR) is reported. Mercury from Mexico originates from primary mining; from Japan, the majority of the mercury is a by-product from zinc smelting, while the mercury from Switzerland is mainly recovered from waste, in particular from chlor-alkali plants. Mercury ending up in Sub-Saharan Africa by official import is estimated to originate to a large extent from these three countries. One South African importer specifically indicated that some of the mercury traded by the company originated from a chlor-alkali plant in Algeria, but according to the official statistics, Algeria is not among the major partner countries. Algeria was a major global producer of virgin mercury in the past, but production allegedly ceased more than a decade ago. Import from Turkey, Ukraine and India may have originated from chlor-alkali plants, but these countries also import mercury, and the actual origin of the mercury has proven difficult to trace.

Anecdotal information suggests that mercury exported from Indonesia to the major mercury trading hubs in Asia may originate from China - the major primary mining producer of mercury globally, as well as the major consumer of mercury. This possibility has not been confirmed. China does not report any export to the UN Comtrade database, but a substance flow analysis of mercury in China in 2011 indicated that more than 100 t/year was exported.

Other anecdotal information suggests that mercury is illegally imported to Sub-Saharan Africa from China along with imported mining equipment. As the import is illegal, it is not possible to confirm this theory, but as the official import is lower than the expected consumption for ASGM, especially in Western Africa, it is likely that some mercury enters the region along with mining equipment; from China or from other countries.

### **Sources of mercury for ASGM in Sub-Saharan Africa**

Based on the available information, it is assessed that imports from countries outside the region represent close to 100% of the supply of liquid mercury in Sub-Saharan Africa. In contrast to other regions in the world, domestic supply from primary mercury mining, by-product production and mercury from recovery of waste appears to be close very small. Small quantities of mercury are probably recovered from mercury-added products using liquid mercury, such as thermometers and sphygmomanometers, but the total amount is estimated to account for approximately 1% of the total mercury supply. No actual examples of mercury recovery have been identified. A trading company in South Africa has informed this study that they can provide approximately 21 t/year of mercury recovered from South African sources (the source not indicated). The information on recovery of mercury in South Africa has not been confirmed from other sources. A questionnaire sent to the countries in the region has not identified any local mercury sources. Mercury supply from national stocks in the region is considered highly unlikely. The region only hosts one small chlor-alkali plant in Angola which is still in operation. The possible supply of mercury from chlor-alkali plants would consequently be from countries outside the region, e.g. in North Africa.

### **Other applications of mercury in Sub-Saharan Africa**

According to the Global Mercury Assessment 2013, the total mercury consumption with mercury-added products in 2010 was 28-38 tonnes, corresponding to about 10% of the total mercury use in the region. The data has been re-evaluated using the methodology of the UNEP mercury toolkit, resulting in a mean estimate about twice the estimate of the Global Mercury Assessment, but with high uncertainty with the data available. The majority of the products are assumed to be imported to the region, as the production of mercury-added products within the region is considered to be minor. Of the mercury in products, about 15 t/year in measuring devices and electrical devices (where mercury is present as liquid mercury) may potentially be collected during disposal and is easily reusable for ASGM. The data indicate that mercury recovered from products would account for a minor portion of the mercury supplied to the ASGM sector at a regional level. The actual recovery is not estimated to be more than some 1-3 tonnes. Mercury could also be recovered by

treatment of mercury lamps and batteries with mercury bound in other materials, but no examples of such treatment has been identified.

As concerns the use in industrial processes, mercury is used in one chlor-alkali plant in Angola. The total consumption is likely about 1 t/year for replacement of mercury in the cells.

### Health and environmental impact

Many studies from Sub-Saharan Africa and other parts of the world demonstrate that individuals involved in the gold mining operations, their families, and other people in the gold mining communities are exposed to dangerous levels of elemental mercury vapor, as evidenced by blood, hair, and urinary mercury concentrations. This evidence includes extremely elevated urinary mercury concentrations in children who work in the mines and children who live in areas where ASGM occurs. Residents in the gold mining communities and downstream of the gold mining communities consume fish that may be heavily contaminated with methylmercury, as demonstrated by high levels of mercury in hair. The health impacts observed in ASGM communities include neurological effects, kidney effects, and possibly immunotoxic/autoimmune effects from mercury exposure.

Releases of mercury from ASGM is estimated to account for 73% of the total atmospheric emissions in Sub-Saharan Africa; ASGM in this region accounts for approximately 12% of the total global anthropogenic emissions of mercury. On top of these atmospheric emissions, significant releases to water bodies and soil take place. Once emitted, the mercury may be transported over long distances and the mercury emitted from ASGM in Sub-Saharan Africa contributes to the overall global mercury burden. The released mercury may be transformed to methyl mercury in the environment which undergoes bioaccumulation and biomagnification in food chains. Exposure studies from diverse geographic areas indicate that a significant portion of humans and wildlife throughout the world are exposed to methylmercury at levels of concern, primarily due to consumption of contaminated fish, but also from local sources like ASGM.

### Control of the flow of mercury to ASGM

Experience shows that it is very difficult to control the trade of mercury within the region by establishing national licensing systems and restrictions, or similar. Once the mercury has entered the continent, it is main-

ly distributed through informal value chains and smuggled across porous borders in small quantities that are difficult to control. Customs departments of several of the participating countries were contacted in the inception phase of the project, and while some reported that they frequently caught smugglers with bottles of mercury, the information obtained was not sufficient or suitable for estimating amounts of mercury smuggled. With the porous borders and the relatively weak enforcement, this is not considered a realistic data source for quantification of unregistered mercury trade (smuggling).

Many countries in the region with mercury use in ASGM already have a license system for trade with mercury in place. This is for example the case in Tanzania, Senegal, Burkina Faso, Zimbabwe, Ghana, Kenya and South Africa. In all these countries apart from South Africa, however, a very small part of the total trade of mercury is undertaken by companies with a license, and registered by the authorities. Introducing licensing systems for mercury trade may actually press the trade into the informal sector, as it was observed in Zimbabwe, where several companies openly advertising mercury sales were reduced to one company when the national licensing system was introduced. Many other examples illustrating the mercury trade challenges are given in the Appendix on country reports.

As more than 90% of the mercury used for ASGM in Sub-Saharan Africa is imported from countries outside the region, control of the mercury flows may be done more efficiently through a close cooperation between the mercury entry countries (e.g. South Africa, Togo and Kenya) and the countries where the mercury is finally used. This approach would however imply a combination of licensing systems and prior consent procedures between the countries with the risk of further concealment mentioned above. Furthermore, limiting the amount of mercury entering the world market, as required in the Minamata Convention on Mercury, is expected to ultimately result in supply shortages and higher prices, which in turn can result in better mercury management by the miners. An obstacle could be if other countries, for example Algeria, which is not signatory to the Minamata Convention, would re-commence production of primary mercury. Supply shortages and prices would be drivers for further application of mercury recovery and mercury-free techniques in the region. Mercury shortage could also be a driver for further development of production of by-product mercury from



industrial-scale gold production and other non-ferrous metal production within the region. The potential for by-product mercury production in the region is however uncertain, and may not be sufficient to seriously hamper the desired decrease of mercury supply.

## Recommendations

### Additional fieldwork and inclusion of NAP results-

The development of the mercury trade estimates in the study has been significantly hampered by the study timing, which was ahead of the ASGM National Action Plan (NAP) development work in the participating countries. This meant that the countries did not have sufficient resources for benefitting optimally from the training given during the study, and for providing data for the study. Significant reduction of the uncertainty of the estimates can be expected through incorporation of data from any additional investigations of ASGM mining sites and mercury trade inspections in the countries, including such work that may be undertaken as part of the country NAPs.

**Guideline methodology** - The guidelines for ASGM baseline inventories and the systems supporting such inventories, developed as part of this study, can be improved. Some of the major elements with potential for improvement are:

- › Defining the number of "miners" more closely (it is used as an extrapolation factor in mercury consumption estimation), as differences in this definition can give rise to systematic errors and substantial uncertainties (the uncertainty is in particular related to whether or not people involved with transportation and processing should be counted as miners).
- › Making the mercury consumption estimation methods more tailored and flexible, in order to respond to the sometimes heterogeneous conditions at mining sites (e.g. the presence of both alluvial and hard rock mining or the presence of various ore grades at various locations). In responding to this, more information has to be collected and processed, and with increased complexity and associated need for training, but the estimation calculations will become more accurate and transparent.

Detailed observations and recommendations for the inventory methodology are given in the Appendix on country reports.

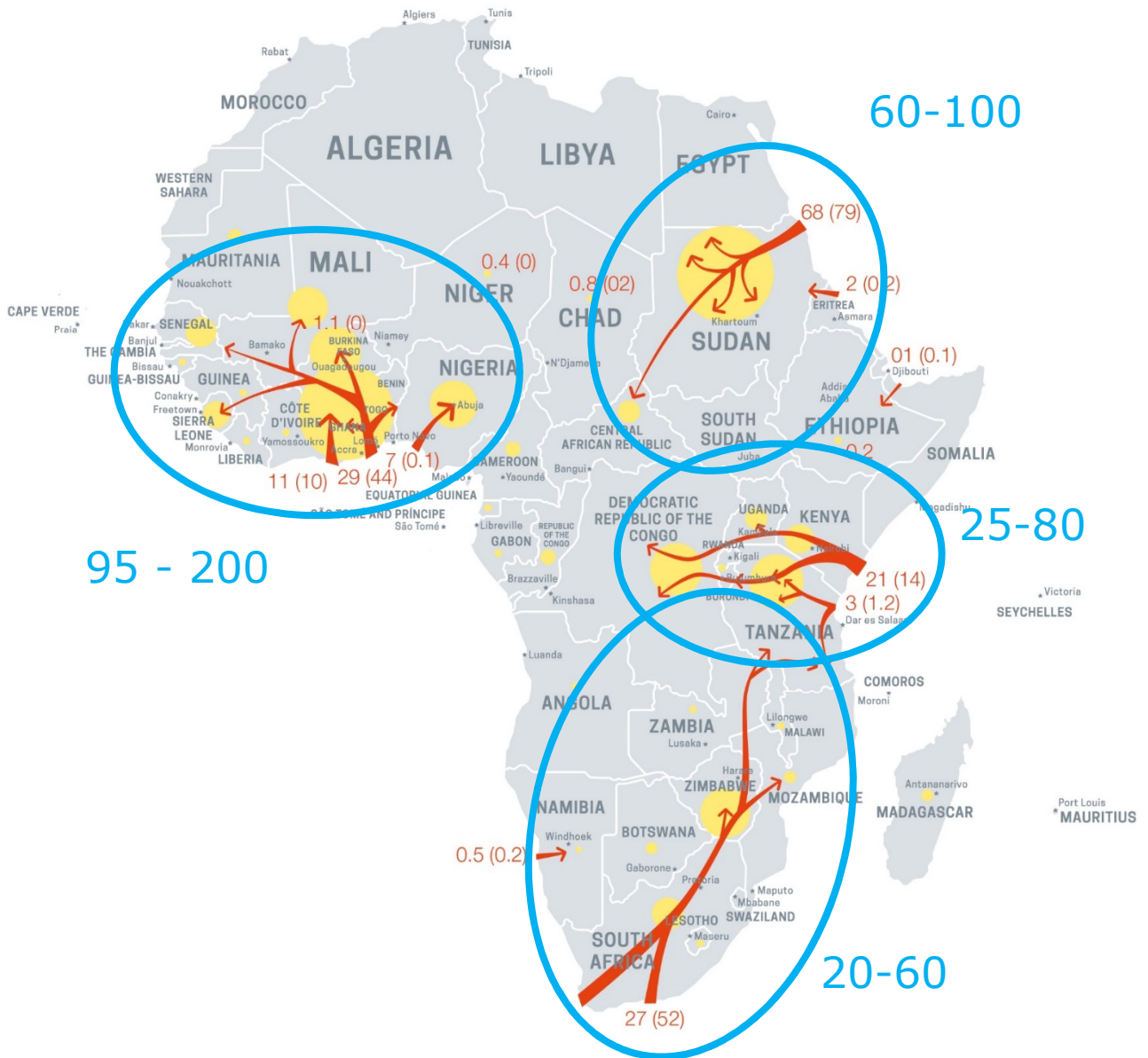
**Mercury trade control options:** As described, controlling the mercury trade in the region may likely be a major challenge. The globally promoted formalization of the ASGM sector is not expected to do the job alone, as the persistence to evade taxes and the sometimes cumbersome bureaucracy seems deeply rooted. The key challenge is to make the ASGM gold trade more transparent. Sudan and Ethiopia are reported to be countries where there has been some success in this respect, and it is recommended to study and potentially benefit from any lessons learned from these countries.

However, global efforts are crucial for controlling the inflow of mercury to the region, and it is therefore imperative that a truly global implementation of the Minamata Convention is promoted, supported and enforced.

A close cooperation between the current mercury entry countries in the region (e.g. South Africa, Togo and Kenya) and the mercury using countries could also play an important role in controlling the trade.

**Promoting use of retorts, fume hoods and mercury-free methods** - The benefits for health, environment and economy from using these readily available release reduction options have not become sufficiently evident for the miners in this region and globally. There are structural and practical challenges hampering a wider application of these techniques, and innovative, massive and consistent initiatives (including an increasing focus on mercury-free methods) are needed for promoting their use, if mercury emissions reductions from ASGM shall succeed.

**Capacity building** - Developing national inventories for the ASGM sector is quite complex, and substantial training and support of government staff and their field operators is needed in order to produce inventories of adequate quality, suitable for development of regulation, training and awareness, and other follow-up activities.



**Figure 0.5**  
 Overall trade flow of mercury in Sub-Saharan Africa. Red numbers indicate the average official import for the period 2010-2015 from countries outside the region with 2015 import figures in brackets. The actual import is may be up to twice the indicated official import. The area of yellow circles indicate the estimated mercury consumption for ASGM in the countries (mean estimate). The blue number indicate the likely total mercury consumption within the sub-regions indicated by the blue circles..



# 1 Introduction

## 1.1 Methodology

A mercury trade diagnostic for Sub-Saharan Africa has been developed by combining information from various sources into an overview of the quantities traded, trade routes, origin of mercury, use of mercury, actors in the value chain, price trends, etc. The available data on mercury supply and mercury consumption for ASGM and other applications in the region are incomplete and sometimes even contradictory, and in the analysis the most likely model and most likely estimates have been developed considering the various available information sources.

In order to obtain a deeper understanding of the trade flows and the actors in the value chains, a more detailed analysis has been undertaken in eight participating countries. By combining the information from the eight countries with a questionnaire and existing information from other countries involved in mercury trade and ASGM, the data from the participating countries have been used for extrapolation to the entire region.

### 1.1.1 Databases and existing surveys and tools

**UN Comtrade database** - Data on import and export have been retrieved from the UN Comtrade database at <http://comtrade.un.org/data/>. In order to be able to extract large data sets, a license was purchased. Data are extracted for the commodity codes for mercury, mercury compounds and amalgams, mercury-added products and gold (see specific commodity codes in the relevant sections and appendixes). Some of the detailed data

are presented explicitly in this report e.g. in the appendixes, whereas for other data only calculated aggregated data are presented. For import of mercury, both import data as registered by the receiver countries in the region and export data to the countries in the region, as registered by partner countries, has been retrieved and compared. Additionally, in order to further analyze the origin of mercury ending up in Sub-Saharan Africa, data for major global export countries for mercury have been analyzed.

**Global Mercury Assessment 2013 (AMAP/UNEP, 2013)** - The Global Mercury Assessment 2013 (GMA) provides estimates for the use of mercury for ASGM for more than 30 countries in Sub-Saharan Africa in 2010. For those countries where newer or more detailed information has not been available for a re-evaluation of the estimated quantities, the estimates of the GMA were used here as best estimate. Furthermore, selected data on the use of mercury in mercury-added products and mercury releases were derived from the GMA.

**UNEP Mercury Toolkit (UNEP, 2005a)** - The possible import/export of mercury in mercury-added products has been estimated by combining data on trade of the products and default input factors from the UNEP Mercury Toolkit. The toolkit includes default factors for mercury content of various products. For certain mercury-added products, the toolkit provides default factors for various mercury-added products on a per-capita basis, which were combined with other country-specific data (on dental health care and electrification rate) to

yield estimates for mercury consumption in each country.

**US Geological Survey Minerals Yearbook** - The Minerals Yearbook from the US Geological Survey for each of the countries in the region has been reviewed in order to extract information on gold production by ASGM and total gold production in each country.

### 1.1.2 Data collection in participating countries

The following countries have participated in the project: Burkina Faso, Côte d'Ivoire, DR Congo, Ghana, Senegal, Tanzania, Uganda and Zimbabwe.

In each of the countries, data have been collected in cooperation between a local specialist and an international specialist, who visited the country during an inception mission and a field training/data collection mission.

**Contact to authorities** - Meetings have been undertaken in all countries with ministries responsible for environmental protection and mining activities, respectively. Furthermore, data on import of mercury have been obtained from customs authorities. Detailed data on import by licensed companies have furthermore been obtained from Ghana, Senegal and Zimbabwe.

**Contact to miners' organizations** - In all countries, ASM miners' organizations have been contacted and meetings have been held with most of the organizations. A list of contacted organizations is included in Appendix 6. The organizations were requested to provide information on organization of the sector in the country, applied methods, number of miners, mercury use, mercury trade and value chains, etc.

**Field investigations** - During field investigations to a limited number of sample sites in the participating countries, information on mercury use and trade was collected by conducting interviews with ASGM miners, mercury brokers and traders, and gold buyers and traders. The information was recorded in interview reports. The published report does not include information which may be associated with specific informants (names and locations), but this information is known to the main authors of the report.

Situations differ among mining sites and countries. Based on the detailed information, some general patterns were identified, but in order to illustrate the varia-

tion, some detailed cases are described from the different countries.

### 1.1.3 Other collection of trade data

In addition to data collection in the eight participating countries, data have been collected through direct enquiry to mercury importers and dealers in South Africa, Kenya and Togo, which are the major mercury importing countries that also export (mainly informally) mercury to other countries in the region. In Kenya and Togo, the project has not been successful in identifying the major importing companies.

### 1.1.4 Questionnaire

A short questionnaire was developed and sent to the countries in the region (see Appendix 7). The questionnaire was kept short, focusing on the main issues for this study, with the aim of obtaining a high response rate.

### 1.1.5 Co-ordination with other trade analyses

Data on the international trade of mercury have been exchanged with Mr. Peter Maxson (Concorde East/West), who is currently undertaking analyses of international trade of mercury. Furthermore, information has been exchanged with Morgane Fritz, University of Graz, working on a PhD on the mercury and gold value chains.

### 1.1.6 Other literature

Workshop reports and literature on ASGM in Sub-Saharan Africa, including various reports from the Global Mercury Project (GMP), have been reviewed in order to extract information on mercury trade, mercury quantities used, value chain of mercury and gold, trend in the use of mercury, number of ASGM miners, etc. Among other applications, this information has been used to re-evaluate the quantities of mercury used in the different countries in the region.

### 1.1.7 Uncertainties

All data available are subject to uncertainty. The uncertainties of estimated quantities are in this study indicated by use of ranges. The ranges are considered as the ranges within which the "true" values are to be found with a 90% certainty. Therefore, for some of the estimates the "true" value may be outside the estimated range.

## 1.2 Countries addressed by the study

The study addresses all countries in Sub-Saharan Africa. According to the UN regional groupings, Sub-Saharan Africa consists of the countries listed below. The countries of this region are divided into sub-regions by the UN as shown on the map below. The names of the sub-regions are used in this report in the discussion of overall trade flows. Note that one of the countries in Northern Africa, Sudan, is included in the Sub-Saharan Africa region, and consequently within the scope of this study.

**Northern Africa:** Sudan

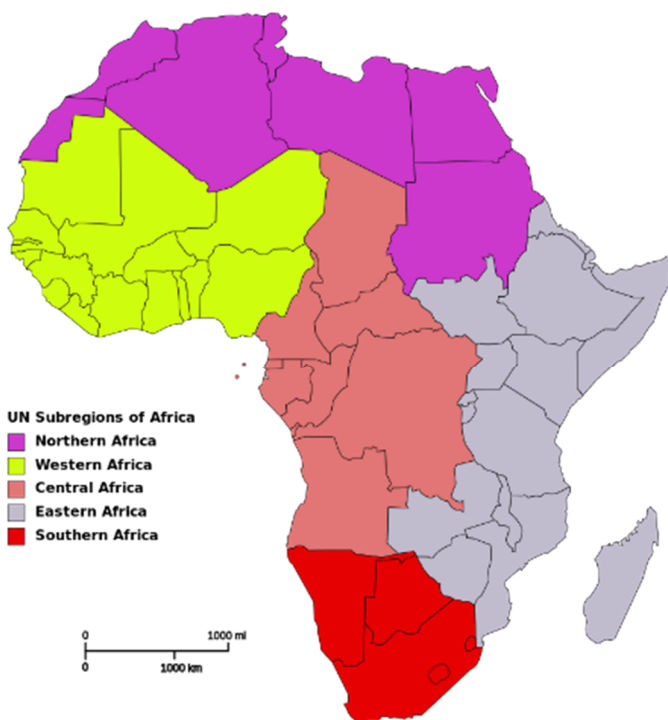
**Western Africa:** Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau,

Liberia, Mali, Mauritania, Niger, Nigeria, Saint Helena, Ascension and Tristan da Cunha, Senegal, Sierra Leone, Togo;

**Central Africa:** Angola, Cameroon, Central African Republic, Chad, Democratic Republic of the Congo (DR Congo), Equatorial Guinea, Gabon, Republic of the Congo, São Tomé and Príncipe;

**Eastern Africa:** Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mayotte, Mozambique, Réunion, Rwanda, Seychelles, Somalia, South Sudan, Uganda, Tanzania, Zambia, Zimbabwe;

**Southern Africa:** Botswana, Lesotho, Namibia, South Africa, Swaziland.



**Figure 1.1**

*UN sub-regions of Africa.  
Source: Wikipedia*



## 2 Mercury trade and value chain

The following section presents a mercury trade diagnostic for Sub-Saharan Africa. The section is based on the official reporting via the UN Comtrade database (based on national statistics) and information on actors in the value chain and the informal trade of mercury, collected mainly by field investigations in the eight participating countries.

### 2.1 International trade of mercury and mercury-added products

#### 2.1.1 Comtrade registered import and export of liquid mercury

Import of liquid mercury as reported to the UN Comtrade database for the period 2010 to 2015 is shown in Table 2.2 while the export is shown in Table 2.3. The data in the Comtrade database is based on the reporting of the custom statistics from the countries. Only countries for which import of mercury or export to the country is reported in at least one year are shown in the table.

In order to analyze the official trade data, two datasets has been retrieved from Comtrade:

- › The registered import to the countries (as reported by the importing country)
- › The registered export to the country (as reported by the exporting countries).

In principle, these data should be similar, but there are often major discrepancies between the datasets, which

can be explained in part by differences in the reporting procedures, and in part by inadequate reporting.

As part of this project, additional detailed import statistics have been obtained from the customs authorities in three of the participating countries. In all of the countries, the data obtained from the customs authorities were identical to the data in the UN Comtrade database. This clearly indicates that the UN Comtrade data actually reflects the national statistics and that inadequate reporting is mainly due to the importers' misreporting to customs.

A comparison of the total registered import for the period 2008-2015 to the six major import countries and the total registered export to these countries as registered by the partner countries is shown in Table 2.1. During this period, the total registered import to the countries was 859 tonnes, while the total registered export to the same countries was 723 tonnes. China does not register export of mercury to any country in Comtrade and export from China is consequently not included in total registered export from partner countries. The total registered import (as registered by the countries) from China to the six countries during the period was 161 tonnes. If this amount is added to the registered export from partner countries, the total would be 884 tonnes, close to the total registered import. However, the data indicate that at least some of the registered import from China is from China Hong Kong SAR (part of China, but a Special Administrative Region). The total registered import from China and China Hong Kong SAR during 2010-2015 was 231 tonnes (163 tonnes from China

and 68 from China Hong Kong SAR) while the total registered export from China Hong Kong SAR was 173 tonnes. The difference is 58 tonnes, possibly indicating that some of the registered import is actually from China (outside Hong Kong SAR). A mass balance of mercury in China indicates an export of 182 tonnes mercury in 2011. Further, more than 200 tonnes mercury had an "unknown fate" (Lin et al., 2016).

The export countries are nearly 100% countries outside Sub-Saharan Africa. Even though the data are uncertain, the export data confirm that these six countries are the main importers of mercury from countries outside Sub-Saharan Africa. As discussed later in this section, the import/export between the countries within the region is largely informal and not registered in the trade statistics (except for trade between South Africa and Zimbabwe in some years). The six countries accounted for 93% of the total registered import and about 95% of the import from countries outside Sub-Saharan Africa.

**Kenya** - For one of the countries, Kenya, the registered export is significantly higher than the registered import, as for many years Kenya did not have registered imports, likely due to misreporting. Significant imports of mercury to Kenya are in accordance with information collected in the field, indicating that a major portion of the mercury used in the gold fields in Northern Tanza-

nia, Uganda and Eastern DR Congo comes from Nairobi, which appears to be a major hub for mercury trade in the sub-region (further described in section 1.1).

**Ethiopia** - For two years, 2013 and 2014, a large import of a total of 390 tonnes mercury to Ethiopia is registered. For other years the registered import is small. The registered export to Ethiopia as registered by partner countries is close to zero for the entire period 2010-2015. The partner country is not indicated and the registered price per tonne is far below the prices registered in other countries. The information collected in the field did not indicate any mercury coming from Ethiopia. Furthermore, according to the available information, the use of mercury in Ethiopia for ASGM is likely in the range of 0.1-0.5 tonnes. For these reasons, the registered imports in 2013 and 2014 are considered to be misreporting. The same two years, no import to Sudan was registered, which may be linked to the registered import in Ethiopia (mercury imported to Sudan via Ethiopia), but during these two years the partner countries still registered export to Sudan.

**Eritrea, Djibouti and Chad** - For these three countries no import is registered, but partner countries have registered export to these countries, primarily to Eritrea where the total registered export during 2010-2015 was 12.9 tonnes.

Country	Trade 2008-2015, tonnes	
	Total registered export to country	Total registered import to country
Sudan /fmr Sudan	223	336
Togo	148	207
South Africa	141	189
Ghana	52	58
Kenya	127	40
Nigeria	32	30
Sum 6 countries	723*	859
Ethiopia	390	0

**Table 2.1**  
Comparison of total registered import to the countries for the period 2008-2015 and the total registered export to the countries as registered by the partner countries\* (Source: UN Comtrade)

\* China does not register export of mercury to any country in Comtrade. The total registered import from China to the six countries during the period was 161 tonnes, but as discussed elsewhere the registered import from China is likely from China Hong Kong SAR

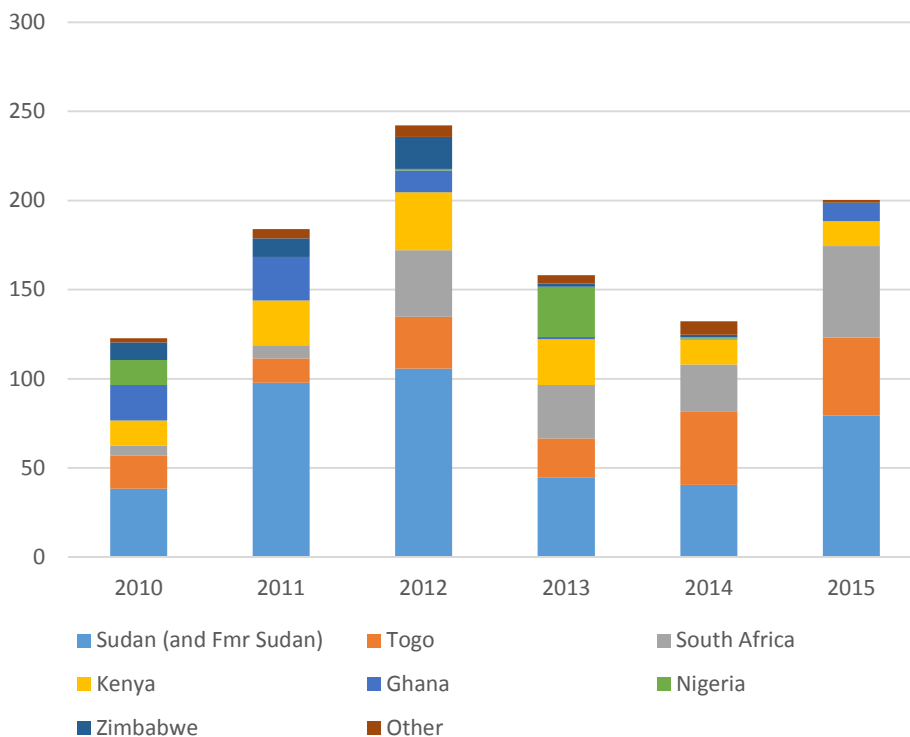
For many of the countries, import is not registered for some years, while an export to the countries is registered for the year concerned. This may be true for some shipments where the container is shipped late one year and arrives early the following year. However, it is more likely due to missing reporting in some years.

For example, Kenya has registered an import of 14.1 tonnes in 2010 and 25.7 tonnes in 2013, but no import in 2011, 2012, 2014 and 2015. This inconsistency may actually be due to periodical reporting but is considered more likely by this study to reflect missing reporting. Exporting countries have reported export to Kenya for

all of those years. In order to compensate for missing reporting for some years, the total export to the countries are used for these years (see Table 2.2 for details). The total registered (corrected) net import 2010-2015 was 1,052 tonnes while the registered export to the countries during the period was 727 tonnes. China does not report export of mercury to any country, but many countries all over the world have registered import from China, among these a total registered import

to Sub-Saharan countries of 163 tonnes during 2010 and 2015. However, an analysis of the available data indicates that at least some of the registered import from China is shipped from China Hong Kong SAR.

The trend in total reported tonnages is shown in Figure 2.1. The total registered net import (import minus export; corrected as explained above) increased from 123 tonnes in 2010 to 244 tonnes in 2012 and was 200 tonnes in 2015.



**Figure 2.1**

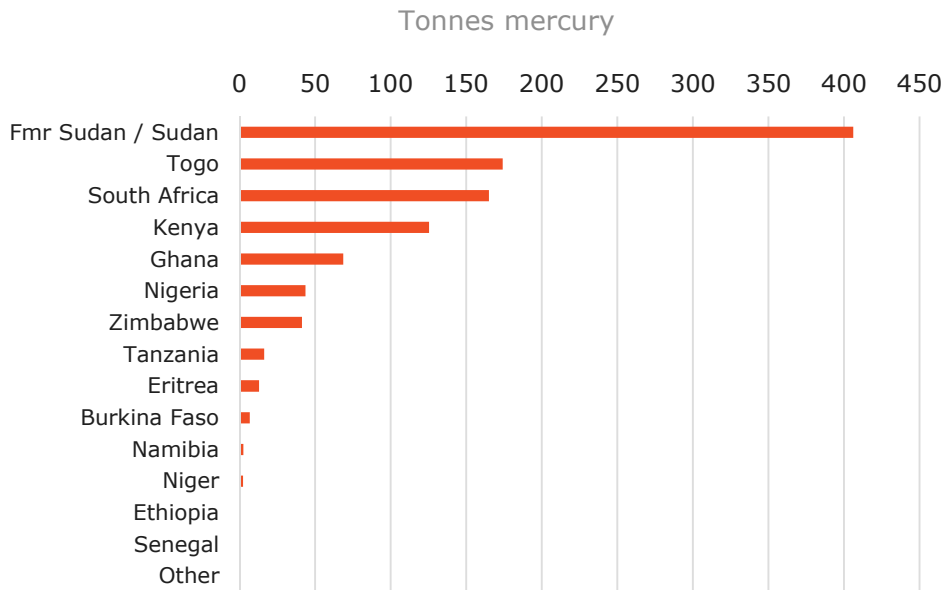
*Total registered net-import of liquid mercury (Customs code 28 05 40) during 2010-2015. For some countries data for export to the countries have been used in absence of import data, see Table 2.2*

Source: UN Comtrade  
**Table 2.2**

The total corrected import for the period 2010-2015 by country is shown in the figure below. The main import countries were Sudan (38% of total), Togo (17%), South Africa (16%), Kenya (12%), Ghana (7%), Zimba-

bwe (4%), Nigeria (4%) and Tanzania (2%). Except for Zimbabwe, the registered import was nearly 100% from countries outside Sub-Saharan Africa.





**Figure 2.2**  
Total registered import of mercury to countries in Sub-Saharan Africa. For some countries data for export to the countries have been used in absence of import data, see Table 2.2

Source: UN Comtrade

**Comparison with the estimated mercury consumption for ASGM**

For Togo, South Africa and Kenya, the recorded import is significantly higher than the consumption for ASGM in 2012 estimated as part of the Global Mercury Assessment and further evaluated in this report (as described in section 3).

**Eastern and Southern Africa and DR Congo** - Based on data collected in the field, Kenya and South Africa serves as hubs for mercury used in ASGM in Eastern and Southern Africa and DR Congo (mainly DR Congo, Uganda, Tanzania, Zimbabwe, Mozambique, and South Africa). The total estimated consumption for ASGM in these sub-regions (and DR Congo) is 55-160 t/year. The total registered net import to all countries in the sub-regions during 2010-2015 was 60 t/year i.e. within the range of estimated consumption for ASG, if in the lower end. Apart from the registered export of mercury from South Africa to Zimbabwe and a few other countries in the sub-regions, trade between the countries appears to be informal. As an example, Kenya did not register any exports at all during 2010-2015, and the total import from Kenya registered by the import countries is 1 kg imported to Uganda in 2012. However, data collected in gold fields in northern Tanzania, Uganda and Eastern DR Congo consistently indicate that the mercury mainly comes via Nairobi.

Import to South Africa and the further export to other countries in southern Africa has been investigated in

detail through enquiry to South African importers and suppliers of mercury as further described in section 2.2.

The registered export to Eritrea was about 2 t/year during 2010-2015. No use of mercury in Eritrea has been reported, but the mercury may have been informally exported to neighboring Sudan with ASGM sites near the borders with Eritrea.

**Western Africa** - Togo serves as a hub for import of mercury in Western Africa and the average registered import of about 30 t/y is significantly higher than the 1-7 t/year estimated to be used for ASGM in the country. The free port in Lomé, Togo, serves as a corridor for import of many commodities to Ghana and other countries in the region. In addition to import via Togo, a significant quantity is imported directly to Ghana and Nigeria. For the three major ASGM countries, Senegal, Mali and Burkina Faso, hardly any import is registered and no export from partner countries outside Sub-Saharan Africa is registered, confirming data collected in the field: that mercury is informally imported from neighboring countries, even though the origin of the mercury is still somewhat uncertain (further described in section 0).

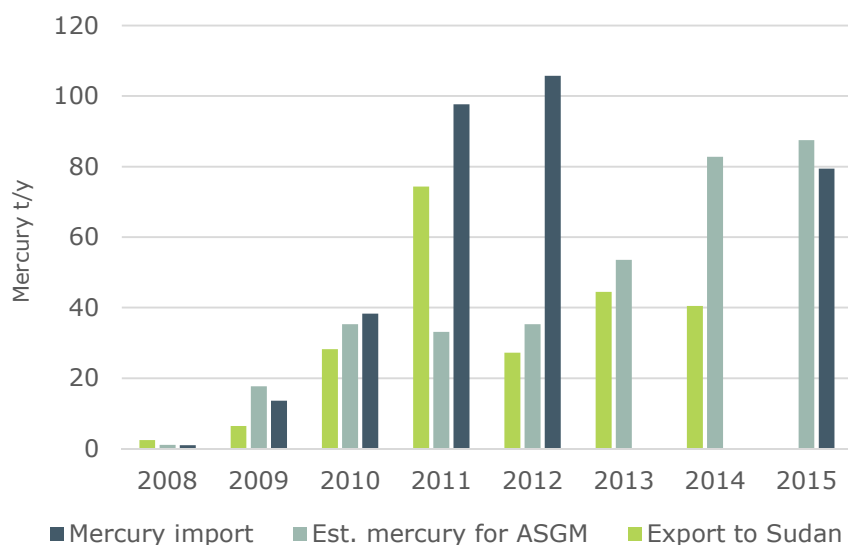
The total estimated consumption for ASGM in Western Africa is 103-214 t/year. The total registered net import to all countries in the sub-region during 2010-2015 was 49 t/year, far below the total estimated consumption for ASGM. This discrepancy indicates that informal, non-registered import from countries outside the sub-region

takes place (which is registered neither by the import nor the export country). A likely route for informal import of mercury is from Northern Africa through the Sahara. For this study, importers in South Africa have stated that some mercury is imported from Algeria (allegedly from a chlor-alkali plant) and from Egypt. Mercury was mined in Algeria in significant quantities until 2004 and it cannot be ruled out that some stockpiles exist in the region (or that informal mercury mining perhaps still takes place).

Apart from a registered export of mercury from Togo to Burkina Faso in 2011 of 6 tonnes, the trade between the countries appears to be informal, a supposition confirmed by data obtained from the field.

**Sudan** - The major importer of mercury in Sub-Saharan Africa is Sudan (until 2011 Fmr. Sudan, consisting of today's Sudan and South Sudan). The mercury imported to Sudan appears mainly to be used for ASGM in Sudan. No export from Sudan has been registered either by Sudan or partner countries. No data indicating import from Sudan has been reported from the field investigations. The registered import increased steeply from around 1 tonne in 2008 to 106 tonnes in 2012. No mercury import was registered in 2013 and 2014 whereas the registered import in 2015 was 79 tonnes. During 2013 and 2014 the registered export to Sudan remained at a level of about 40 t/year. The total consumption for ASGM in 2011 is estimated at 30-90 t/year in the Global Mercury Assessment (see section 3.1). A detailed inventory of ASGM sites and gold production in

Sudan has recently been published (Ibrahim, 2015). According to the study, total gold production has been steadily increasing from a level of around 10 tonnes in 2008, to over 32 tonnes in 2010 to 73 tonnes in 2014 (and 62 tonnes for first 3 quarters of 2015). About 85% of the gold was produced by ASGM. It is indicated in the report that the gold produced by ASGM is extracted by amalgamation. If a mercury to gold ratio of 1.3 is applied (amalgamation from concentrate), the 64 tonnes gold produced by ASGM in 2014 corresponds to 83 tonnes mercury. The estimated mercury consumption is shown in the figure below along with trade data. Until 2011, the data also covered what is currently South Sudan. According to a report on mining in South Sudan from Cordaid (2016), mercury is not used for artisanal gold mining in South Sudan as other methods are applied. Data for all years are consequently assumed to represent today's Sudan. The trend in import of mercury follows the estimated trend in the use of mercury for ASGM in the country quite well. Total estimated mercury consumption during the period 2008-2015 is estimated at 346 tonnes while the total registered import is 336 tonnes. The missing import data in 2013 and 2014 may be due to the accumulation of excess mercury from previous years, but as export to Sudan is registered by export countries in that period, it is assumed that the missing registered import is due to misreporting. The export registered by partner countries in 2013 and 2014 is therefore used as a best estimate for the import.



**Figure 2.3**

Registered mercury import to Sudan, export to Sudan as registered by partner country and estimated mercury use for ASGM. Mercury consumption has been estimated from reported gold production assuming that 1.3 g mercury is used to produce 1 g of gold. Total mercury consumption in 2015 has been extrapolated from data for the first three quarters of 2015.

Source: UN Comtrade and Ibrahim, 2015



	2010	2011	2012	2013	2014	2015	Total 2010-2015	Total export to country
Kenya	14,078	nd (25,168)*	nd (32,491)*	25,774	nd (14,022)*	nd (14,009)*	125,542*	120,693
Madagascar	1	2	1	nd	1	nd	5	9
Mali	8	nd	nd	nd	nd	nd	8	4
Mauritania	nd	nd	nd	nd	9	nd	9	3
Mauritius	nd	nd	2	nd	nd	nd	2	nd
Mozambique	nd	nd	18	nd	nd	nd	18	194
Namibia	nd	902	1,481	311	15	nd (154)*	2,863*	733
Niger	nd	2,241	37	60	nd	nd	2,338	nd
Nigeria	nd (13,966)*	nd (104)*	789	28,255	655	0 (100)*	43,869*	32,123
Rwanda	30	nd	nd	nd	nd	nd	30	3
Senegal	372	nd	nd	nd	nd	nd	372	25
South Africa	5,582	7,979	39,555	32,289	28,089	51,547	165,041	135,013
Sudan (and Fmr Sudan)	38,313	97,694	105,723	nd (44,516)*	nd (40,504)*	79,422	406,172*	221,775
Togo	18,731	19,809	29,005	21,997	40,982	43,750	174,274	130,750
Uganda	nd	100	47	4	128	155	434	628
United Rep. of Tanzania	nd	1,312	2,171	4,344	7,382	1,203	16,412	3,195
Zambia	nd	nd	50	nd	nd	nd	50	649
Zimbabwe	9,961	10,402	17,916	121 (1,688)*	94 (1,359)*	9	41,335*	9,661
<b>Total*</b>	<b>122,858*</b>	<b>198,143*</b>	<b>249,939*</b>	<b>161,483*</b>	<b>139,811*</b>	<b>201,269*</b>	<b>1,073,503*</b>	<b>737,012</b>

Source: Comtrade database. Only countries with a registered import in at least one year are included.

\* Data for export to the countries as reported by partner countries are indicated in brackets. These data are used as best estimates for import and are included in totals marked with asterisk \*.

Table 2.3 Export of mercury (Customs code 28 05 40) 2010-2014 in kg by country\* Please note that this is different from the discussed export to the countries

	2010	2011	2012	2013	2014	2015	Total 2010-2014
Botswana	15	nd	nd	nd	nd	nd	15
Mali	nd	2,550	nd	nd	nd	nd	2,550
South Africa	180	746	2,213	2,318	1,503	272	7,232
Togo	nd	6,038	nd	nd	nd	nd	6,038
<b>Total</b>	<b>195</b>	<b>9,334</b>	<b>2,213</b>	<b>2,318</b>	<b>1,503</b>	<b>nd</b>	<b>15,835</b>

\* Source: Comtrade database

## 2.1.2 Origin of mercury imported to Sub-Saharan Africa

As further discussed in section 2.3 on mercury sources, nearly 100% of the mercury used in Sub-Saharan Africa is imported from countries outside the region. Historically, the majority of the mercury originated in Europe (Spain) which once was the major producer globally of mercury from primary mining. Furthermore, large amounts of excess mercury from decommissioning of chlor-alkali plants in Europe was exported to Sub-Saharan Africa and other regions of the world. The mercury export bans in the EU, effective from 15 March 2011, have changed the import pattern. Export to Sub-Saharan Africa from the EU before the export ban went into force is further discussed in the next section 2.1.3.

The distribution of import to Sub-Saharan Africa by partner countries in 2014 and 2015 is shown in Table 2.4. Both total import as reported by the import country and total export as reported by partner countries are shown. Major partner countries confirmed by both the import and export data are China Hong Kong SAR, Switzerland, Singapore, Turkey, India, Mexico, Japan, and United Arab Emirates.

A major import from China is registered. A closer analysis of all import and export data for China and China Hong Kong SAR<sup>2</sup> for the period 2010-2015, mentioned further below, indicates that some of the mercury registered as exported from China Hong Kong SAR is registered as import from China by the importing countries. It is possible that some of the mercury registered as import from China was in fact imported from China outside Hong Kong, but overall it is considered more likely that the importer did not distinguish between China and China Hong Kong SAR.

China, China Hong Kong SAR and Singapore represent in total 59% of the registered import and 64% of the registered export.

Of the main exporters to Sub-Saharan Africa, most of the countries are among the main exporters in the world, as described further below where the possible origin of the mercury is discussed: China Hong Kong SAR, Switzerland, Singapore, India, Mexico, and Japan together represent 78% of registered import and 76% of registered export to the region. Turkey and United Arab

Emirates are not among the main global export countries, but the export from these countries to Sub-Saharan Africa is in any case confirmed by both import and export data. For the entire period 2011-2015, export from Turkey to Sudan was registered. The origin of mercury from Turkey and United Arab Emirates is not known, but United Arab Emirates appears to be a trading hub for mercury in the same way as described for Singapore and China Hong Kong SAR below.

Some import from countries with an export ban is registered: USA, The Netherlands, United Kingdom, Italy and Germany and France, but this import is not confirmed by export data. It may indicate some illegal export from the countries, but may also be due to misreporting regarding the country of origin.

South Africa is the only country within the region with any significant registered export; however, registered export from South Africa is considered far below its actual export to other countries in the region, as discussed elsewhere.

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<sup>2</sup> China, Hong Kong Special Administrative Region

*Table 2.4 Total recorded import to countries in Sub-Saharan Africa by partner country as registered by the Sub-Saharan countries and partner countries (Source: Comtrade)*

Partner country	Total recorded import to countries in Sub-Saharan Africa		Total recorded export to countries in Sub-Saharan Africa	
	2014-2015 tonnes	% of total	2014-2015 Tonnes	% of total
China	89.7	35.4%	-	-
China Hong Kong SAR	46.3	18.3%	57.2	29.7%
Switzerland	22.8	9.0%	2.2	1.2%
USA	22.1	8.7%	-	-
Singapore	14.3	5.6%	65.7	34.2%
Turkey	14.2	5.6%	5.6	2.9%
India	10.4	4.1%	11.2	5.8%
Mexico	6.9	2.7%	10.0	5.2%
Japan	6.9	2.7%	-	-
United Arab Emirates	6.1	2.4%	29.4	15.3%
Netherlands	4.2	1.7%	-	-
United Kingdom	2.9	1.1%	-	-
Ukraine	1.7	0.7%	6.9	3.6%
Guatemala	1.7	0.7%	1.9	1.0%
Italy	1.7	0.7%	-	-
Germany	1.2	0.5%	0.0	0.0%
Malaysia	0.3	0.1%	-	-
South Africa	0.1	0.0%	1.8	0.9%
Namibia	-	-	0.2	0.1%
France	-	-	0.0	0.0%
<b>Total</b>	<b>253.5 *</b>	<b>100%</b>	<b>192.2</b>	<b>100%</b>

\* The total is less than the total for the two years as indicated in Table 2.2, because the data in Table 2.2 have been corrected for anticipated missing import data.

After the entering into force of the EU mercury export ban, East Asian countries have emerged as major mercury trade hubs. The importance of these countries for the mercury trade in 2013-2014 has been illustrated by

Maxson (2016a) and shown in the figure below. Among the importers of mercury from the three countries are Kenya, South Africa, Sudan and Togo, the major import countries in Sub-Saharan Africa.

IMPORTERS	MAIN E. ASIAN EXPORTERS			TOTAL
	* JAPAN	SINGAPORE	HONG KONG	
BRAZIL	19,490	8,453	25,123	53,066
COLOMBIA	8,624	11,213		19,837
GUYANA			35,186	35,186
KENYA		16,906	12,356	29,262
INDONESIA		126,623		126,623
MYANMAR		10,355		10,355
PAKISTAN	6,638			6,638
PERU		10,350		10,350
SOUTH AFRICA		30,092	18,495	48,587
SUDAN			21,812	21,812
TOGO		6,900	39,181	46,081
INDIA	72,448	32,430	40,548	145,426
SINGAPORE	24,684		29,786	54,470
OTHERS		150,938	24,150	175,088
<b>TOTAL (Kg)</b>	<b>131,884</b>	<b>404,260</b>	<b>246,637</b>	<b>782,781</b>

● Mercury exports (kg) for 2013-14 (countries receiving <4 metric tons mercury are not listed)  
● Importers with significant ASGM activities are marked in yellow  
● Importers that re-exported mercury to ASGM countries in 2013-14 are marked in red  
● Other importing countries are marked in turquoise

**Figure 2.4**  
Major Asian traders of mercury in 2013-2014 (Maxson 2016a; graphic produced by Natural Resource Defense Council (NRDC), with permission from the author)

The trend has continued in 2015. Export of mercury from the major export countries is shown in Table 2.5.

The table excludes export of mercury from EU countries to other EU countries. The total export from the countries in 2015 was 735 tonnes. Some of the countries trade mercury and may be importers of mercury from other export countries. The total net export from the countries (total export minus total import from/to the countries) was 377 tonnes.

**Mexico** – According to reported data, Mexico is presently the main exporter of mercury in the world with a recorded export of approximately 300 t/year. The mercury originates from primary mercury mining. The majority is exported for use in ASGM in countries in South America, whereas only a fraction is exported to countries in Sub-Saharan Africa. Of the total recorded export of 307 tonnes in 2015, 1.7 tonnes were exported to Kenya and 5.2 tonnes to South Africa. South Africa reported an import of 6.9 tonnes from Mexico while Kenya did not report an import. Of the total recorded export of 301 tonnes in 2014, 2.6 tonnes were exported

to Kenya and 0.6 tonnes to Eritrea. Neither of the two countries recorded an import. Seventeen tonnes were exported to Singapore in 2014, from which the mercury may have been re-exported to countries in Sub-Saharan Africa.

**Japan** - The import to Japan is close to zero, i.e. the exported mercury is likely generated within the country itself. The mercury originates as a by-product from the production of zinc concentrate. According to Yasuma (2010), more than 100 t/year of mercury was recovered in 2010 from mercury-added products and by-products from smelters. According to Maxson (2009), mercury by-products from zinc smelting in Japan amounted to 67 tonnes in 2008.

**Switzerland** - The origin of the mercury is likely recovery from mercury waste including waste from chlor-alkali or mercury from decommissioned chlor-alkali plants. Switzerland has traditionally imported mercury waste from the EU for recovery. Maxson (2016a) describes how in the period 2011-2013 the German company DELA illegally exported about 500 tonnes of mer-

cury from decommissioned chlor-alkali plants in the EU to Switzerland. The mercury was likely re-exported from Switzerland to other countries.

**Singapore and China Hong Kong SAR** - As described above, these countries are hubs for mercury trade. The mercury is imported from various countries, as further described below, and exported mainly to ASGM countries.

**India** - This country sees extensive import and export of mercury, and appears to serve as a trading hub as well, but differs from Singapore and China Hong Kong SAR as it also has significant consumption of mercury and possibly generation of waste mercury including waste from chlor-alkali plants.

**China** - China does not report to Comtrade and export of mercury is prohibited. In 2015, a total import of 63.8 tonnes was registered as imported from China by 11 countries, with Togo and Sudan as the major import countries. An analysis of registered export from China Hong Kong SAR and import from China and China Hong Kong SAR for the period 2010-2015 indicates that many import countries register the mercury as imported from China, while it is actually registered as exported from China Hong Kong SAR. The total regis-

tered export from China Hong Kong SAR during 2010-2015 was 759 tonnes while the total registered import from China in addition to China Hong Kong SAR during the same period was 597 tonnes, i.e. the total registered import from the two "countries" was 200 tonnes lower than the registered export from China Hong Kong SAR. The data for countries in Sub-Saharan Africa indicates the same. During the period 2010-2015 the total import to the region was registered as 163 tonnes from China and 65 tonnes from China Hong Kong SAR (for a total of 231 tonnes). The total export to the region registered by China Hong Kong SAR was 173 tonnes (58 tonnes less). Both datasets indicate that at least some of the registered import from China cannot be explained as import from China Hong Kong SAR and should be added to the total import.

**Prices** - The trend in world market prices of mercury is further described in section 2.2.1. The average price of exported mercury from the countries differs significantly, with prices in the range of USD 459 to 627 per 34.5 kg flask from India, China and Switzerland and prices in the range of USD 1,093 to 1,926 per flask from Japan, Singapore, China Hong Kong SAR and Mexico. As discussed below, these price differences may in part reflect varying quality of the mercury traded.

**Table 2.5**

*Total export of mercury from the main export countries in 2015 and price of traded mercury (excluding countries within the EU exporting to other EU countries); as reported by the export countries (Source: Comtrade)*

	Value, USD	Export from country, tonnes	USD per kg	USD per 34.5 kg flask	Import to country, tonnes	Origin of mercury
Japan	3,240,777	102.3	32	1,093	<0.1	By-product from zinc smelting; waste mercury
India	848,590	63.8	13	459	153.9	Trading; possibly waste mercury
Singapore	6,460,898	140.4	46	1,587	125.9	Trading
China Hong Kong SAR	1,127,753	20.2 *	56	1,926	78.0	Trading
Mexico	13,909,189	306.7	45	1,565	0.1	Primary mercury mining
Switzerland	1,853,933	102.1	18	627	<0.1	Waste mercury; previous import of mercury from chlor-alkali plants in the EU
<b>Total</b>	<b>27,441,140</b>	<b>735.4</b>	<b>37</b>	<b>1,287</b>	<b>357.9</b>	

\* The quantity was very low in 2015 compared to previous years. Total for the period 2010-2015 was 759 tonnes. Total registered import to partner countries in 2015 was 45 tonnes (to Sudan).



### Origin of mercury exported from Singapore, China Hong Kong SAR and Mexico

The mercury exported from Singapore and China Hong Kong SAR originates from various countries. In 2015, the major exporter of mercury to the two countries was Indonesia. Maxson (2016a) states that mercury mines have reportedly begun operating in Indonesia and that Indonesia furthermore generates mercury as a by-product from gas production. Singapore at the same

time exports significant amounts of mercury to Indonesia, which has an estimated consumption for ASGM of 122-238 t/year (UNEP, 2013).

Malaysia has, similar to Singapore and Hong Kong SAR, significant import and export of mercury. The mercury likely does not originate in Malaysia; the data illustrates that some of the mercury circulates between different traders in different countries.

**Table 2.6**

*Import to Singapore, China Hong Kong SAR and India in 2015 by partner country (as registered by the import country) (Source: Comtrade)*

Country	Partner country	Value, USD	Tonne	USD per 34.5 kg flask
Singapore	Indonesia	1,733,503	70.4	849
	Japan	492,070	17.3	984
	Switzerland	543,231	18.6	1,006
	Thailand	7,477	2.6	101
	Ukraine	292,917	6.7	1,502
	USA	451,124	10.4	1,504
	Total			126.0
China Hong Kong SAR	Indonesia	639,490	34.8	634
	Malaysia	38,699	22.6	59
	Singapore	339,460	20.6	569
	Total			78.0
India	China	226,459	2.6	2,961
	Germany	32,595	0.2	5,919
	Indonesia	62,673	2.1	1,027
	Japan	2,245,770	68.0	1,140
	Mexico	724,943	22.3	1,124
	The Netherlands	429,693	10.4	1,432
	Singapore	271,476	8.5	1,108
	Switzerland	116,108	3.1	1,281
	Ukraine	1,071,153	23.1	1,599
	USA	1,239,595	13.7	3,126
	Total			153.9

## Trend in import to and export from Singapore

Singapore is one of the main hubs of international mercury trade. Over the last ten years the registered mercury import to and export from Singapore has fluctuated markedly. During the period 2011-2012, 1,100 tonnes mercury in total was imported to Singapore. The majority of this import was from the EU and USA, indicating a

large amount of mercury was sold immediately before the export bans went into force. Via Singapore, the mercury was directed to countries with ASGM, among which were countries in Sub-Saharan Africa. Although to a less extent, the same has been the situation as concern China Hong Kong SAR which e.g. imported 311 tonnes mercury from the USA in 2012.



**Figure 2.5**

*Trend in import to and export from Singapore 2006-2015*

## Global mercury supply sources

No recent updates of the global mercury supply exist; the latest survey dates back to 2006 (Maxson, 2006). The 2006 data are shown in the table below. The majority of the mercury from decommissioned chlor-alkali

cells originated from decommissioning of chlor-alkali plants in Europe. This supply source has ceased as a consequence of the EU mercury export ban. The total supply of 1,800-2,200 t/year from mercury mining and by-product mercury was slightly lower than the quantity estimated by USGS (2016) of 2,350 t/year in 2014.

Sources of mercury supply	Mercury supply, t/year
Primary mercury mining and by-product mercury	1,800 - 2,200
Recovered mercury from chlor-alkali wastes	90 - 140
Recycled mercury - other	450 - 520
Mercury from decommissioned chlor-alkali cells	600 - 800
Stocks	0 - 200
<b>Total</b>	<b>3,000 - 3,800</b>

**Table 2.7**

*Global mercury supply in 2005 (Maxson, 2006)*

## Mercury mining

The USGS Minerals Yearbook 2014 on mercury (the most recent) includes a survey of primary mercury mining and mercury by-product mining. The data for 2010

and 2014 are shown in the table below. USGS notes that world mercury production estimates have a high degree of uncertainty because most companies and countries do not report principal mine, byproduct mine,

or recycling data. Quantities may appear erratic from year to year because production may not be reported until shipped and stockpiling may take place prior to shipment. The data for Mexico is based on export data. In the period 2013 to 2015, the total export from Mexico was about 300 t/year. A substance flow analysis of the intentional use of mercury in China estimates the total primary mercury mining in China in 2011 at 774 tonnes.

**Table 2.8**  
*Estimated world mine production of mercury by country (USGS, 2016)*

Country *	2010	2014 <sup>e</sup>	Type ***
Argentina	25	10	Not indicated
Chile	176	10	By-product
China	1,600	1,600	Primary mercury mining
Finland	9	-	By-product ***
Kyrgyzstan	99	75	Primary mercury mining
Mexico**	15	500	Primary mercury mining***
Morocco	10	8	Not indicated
Norway	25	25	By-product ***
Peru, exports	159	40	By-product
Russia	50	50	Not indicated
Tajikistan	15	30	Not indicated
United States ****	Not available (NA)	Not available (NA)	By-product
<b>Total</b>	<b>2,180 (+ NA)</b>	<b>2,350 (+ NA)</b>	

Notes (as noted by USGS):

- \* Canada and Spain are thought to produce byproduct mercury, but information on production is inadequate to make reliable estimates.
- \*\* Beginning in 2011, data for Mexico were based on net exports.
- <sup>e</sup> Estimated

Notes to the current report: \*\*\* Type as estimated in this report based on other knowledge.

\*\*\*\* An analysis of alternatives for the long-term management of excess mercury in the USA, estimated that about 100 t/year is produced as by-product from gold mining in the USA (U.S. DoE , 2011)

### Summary on origin of imported mercury

Mercury from primary mine production may end up in Sub-Saharan Africa either by direct export from producer countries (total registered import from China in 2015: 59.2 tonnes; from Mexico: 6.9 tonnes) or it may be imported via some of the main global mercury hubs such as India, Singapore or China Hong Kong SAR. The quantities of mercury originating from mining activities traded via the hubs are not known.

The majority of the more than 100 tonnes mercury exported from Japan is by-product mercury from zinc

The total export from China is estimated at 182 tonnes in the analysis. Based on these estimates, the 1,600 t/year estimated by USGS may be an overestimate.

According to Maxson (2009), mercury by-product from zinc smelting in Japan amounted to 67 tonnes in 2008. Mercury by-product in Japan is not included in Table 2.8.

smelting. A part of this amount is exported directly to Sub-Saharan Africa (6.7 tonnes in 2015) or imported via India or Singapore, the major importers of mercury from Japan.

Notably, no direct import to Sub-Saharan Africa from other countries with mercury from mine production (e.g. Kyrgyzstan or Peru) is registered.

Part of the approximately 100 tonnes mercury exported from Switzerland in 2015 is exported directly to Sub-Saharan Africa (22.8 tonnes in 2015) or possibly im-

ported via India or Singapore, among the major importers of mercury from Switzerland. The mercury likely originates from recovery of mercury from waste or from decommissioned chlor-alkali plants.

### 2.1.3 Former export of mercury from the EU to Sub-Saharan Africa

Prior to the EU mercury export ban, significant amounts of mercury were exported to countries in Sub-Saharan Africa as documented by EU export statistics. The data from EU export statistics are considered relatively reliable, and the data on former export from the EU may supplement other information on import of mercury to the countries. The former import from the EU has now been replaced with import from other countries without export bans.

In order to analyze the export data for the European Commission, COWI and BIPRO compared the data on export from EU28 Member States (MS), as reported in the Eurostat database, with the data on imports from EU reported by non-EU importing countries to the UN Comtrade database (Zettl et al., 2015). In principle, the reported exports by the Member States should be the same as the reported imports from Member States by non-EU importing countries. The tables from Zettl et al. (2015) have been supplemented with data collected in this project.

In Table 2.9, exports of mercury (CN code 28054010 + 28054090) from EU28 to the Sub-Saharan African countries are shown by import country during the period 2005-2011 (before the mercury export ban entered into force) and 2012-2013 (after the export ban) and compared with import data by importing countries provided in the UN Comtrade database.

The total export from the EU to Sub-Saharan Africa as recorded by Eurostat was 270 tonnes during the period 2005-2011 (annual mean of 39 t/year), while the total import to the countries as recorded in UN Comtrade was 279 t/year (annual mean of 40 t/year). Even though some differences between recorded export and import appear for the individual countries, it is notable that for the region as a whole the data correspond quite well. For the period 2012-2013, i.e. after the EU export ban, the recorded import is significantly higher than the recorded export from the EU, which may be due to some illegal export from the EU after the ban entered into force (export under other commodity codes) or the mercury may have been exported before the ban, but not registered as imported until the subsequent year.

The major import countries were the same as during the period 2010-2015 reported in this study, with the exception that some direct export to Burkina Faso takes place in the period 2005-2011.

*Table 2.9 Export of mercury from EU28 by importing country 2005-2011 and 2012-2013. (Source: Comtrade)*

Country	Export of mercury from EU28 Total 2005-2011 Eurostat tonnes *	Import of mercury from EU28 2005-2011 UN Comtrade tonnes**	Export of mercury from EU28 Total 2012-2013 Eurostat tonnes *	Import of mercury from EU28 2012 -2013 UN Comtrade tonnes**
Benin	0.20	0.21	0.00	nd
Burkina Faso	38.70	4.00	0.00	nd
Burundi	0.00	0.00	0.00	nd
Cameroon	0.00	0.01	0.00	0.01
Cape Verde	0.30	0.01	0.00	nd
Congo	2.30	nd	0.00	nd
Cote d'Ivoire	0.90	0.06	0.00	nd
Ethiopia	0.00	0.16	0.00	0.00
Gabon	0.00	0.01	0.00	nd
Gambia	0.00	0.00	0.00	nd
Ghana	46.00	59.90	0.00	0.01
Kenya	29.80	50.57	0.00	0.86
Madagascar	0.00	0.06	0.00	nd
Mali	0.00	0.04	0.00	nd
Mauritius	0.00	0.00	0.00	nd
Mayotte	0.00	0.23	0.00	nd
Mozambique	0.00	0.00	0.00	nd
Niger	0.10	2.24	0.00	0.04
Rwanda	0.00	nd	0.00	0.00
Senegal	0.40	0.42	0.00	nd
South Africa	21.50	26.12	0.00	28.09
Sudan (Fmr Sudan)	35.80	35.99	0.00	13.18
Togo	79.20	62.3	0.00	2.15
Uganda	0.00	0.10	0.00	nd
Tanzania	0.90	12.2	0.10	1.13
Zambia	0.20	0.01	0.00	nd
Zimbabwe	14.60	24.43	0.00	7.30
<b>Total</b>	<b>271</b>	<b>279</b>	<b>0.10</b>	<b>52.77</b>

\* Sources: Eurostat database: 'international trade detailed data'; total of CN codes: 2805 4010 and 2805 4090.

\*\* Source DESA/UNSD, United Nations Comtrade database; CN code: 280540 (the sum of CN codes 2805 4010 and 2805 4090).

### 2.1.4 Trade statistics for mercury compounds, amalgams and mercury added products

The following section includes trade data on dental amalgams, mercury compounds and other mercury-added products.

#### Amalgams of precious metals

The Comtrade database includes data on amalgams under code 2843 90; "Precious metal compounds except gold, silver, amalgams" with the description "Other compounds; amalgams", listed under code 2843 "Precious metal colloids, compounds and amalgams". Amalgams of non-precious metals are included in code 2851 along with many other chemicals. Data have not been retrieved for this aggregated commodity group.

The amalgams of precious metals may cover dental amalgams where the mercury is amalgamated with silver and other metals. However, according to the UNEP/WHO project "Promoting the phase down of dental amalgam in developing countries" (UNEP, 2014), customs declarations and tariff codes generally label dental amalgam as "medical devices" and it is not possible to separate amalgams from statistics on other "medical devices" in the same category.

The possibility exists that imported liquid mercury is recorded as amalgam because the import of mercury amalgam for dental applications is generally not restricted, whereas in some countries mercury for ASGM is. For those countries where the actual import of mercury is potentially higher than the registered import, however, no significant import of amalgam is registered (e.g. Ghana, Togo, Kenya, and Nigeria).

Net import of amalgams of precious metals as compared with the assumed consumption of mercury in dental amalgams in each of the countries is shown in Appendix 4.

The consumption of mercury in amalgams per country is calculated from average mercury content of dental amalgams, population and density of dental personnel using the algorithm of the UNEP Mercury Toolkit (UNEP 2015a). The total estimated consumption of mercury in amalgams of 5.3 t/year using the UNEP Toolkit is in accordance with the consumption of mercury in the region estimated for the Global Mercury Assessment of 5-7 t/year (see Table 3.3)

The total net import of amalgam was 367 tonnes for the period 2010-2014, corresponding to an average of 73.5 t/year. The large figures for Mauritania and Ethiopia are not confirmed by any export to the two countries. The export to South Africa, mainly originating from Germany, is confirmed by the export country data. If the data from Mauritania and Ethiopia are excluded, the average is 30 t/year. If this amount is assumed to be dental amalgam with a mercury content of 50%, the mercury content would be 15 t/year or about twice the estimated consumption in dental amalgams.

As for the mercury, the only significant trade within the region is between South Africa and Zimbabwe. The import of the two commodities to Zimbabwe from South Africa could indicate that imported mercury is registered to some extent as import of amalgam. During 2008 and 2015, as discussed elsewhere, the registered import of mercury to Zimbabwe from South Africa decreased from 9 tonnes in 2008 to a few hundred kg during the period 2013-2015. During the same period the import of amalgam increased. However, the registered import, even if the amalgam is assumed to be mercury, remains far below the estimated actual import from South Africa.

From several of the participating countries it has been reported by stakeholders that the dental amalgam is most commonly traded as dental capsules with liquid mercury parts and parts with other metals to be mixed immediately before application. The price of the capsules is so high that it would not be economical to use the mercury from the capsules for ASGM. On the other hand, some information indicates that liquid mercury is sold from pharmacies for legal dental application, but its actual use is in ASGM. This possibility will be further investigated at the ASGM sites during field work.

#### Mercury compounds

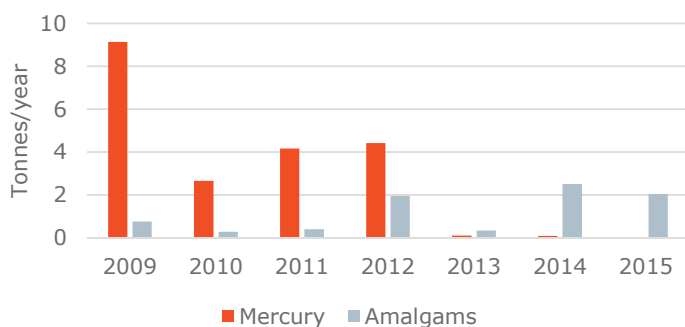
Trade data for mercury compounds are shown in Appendix 3. Mercury compounds may include e.g. mercury oxide for manufacture of batteries. The statistics are characterized by very high import volumes in some years in some countries and are most likely due to flawed reporting, but periodic trade at favorable prices cannot be ruled out.

According to the available information, mercury batteries and mercury containing lamps are not produced in the region. It is reported that batteries are manufac-

ured in Senegal and these may contain some mercury: The batteries were not of the mercury-oxide type.

Some mercury compounds may be imported e.g. for manufacture of skin-lightening cream (e.g. ammoniated

mercury) and use as cosmetics preservative in e.g. eye makeup (e.g. thiomersal and phenyl mercuric salts). Furthermore, some mercury compounds may be used for polyurethane production.



**Figure 2.6**  
Registered import of mercury and amalgam to Zimbabwe from South Africa

### Other mercury-added products

The import of mercury-added products, fluorescent lamps and batteries, is shown in Appendix 3. The intention has been to estimate the total import of mercury with these products using default factors of content from the UNEP Toolkit and assess to what extent mercury recycled from mercury-added products (even if it may not take place in the region today) may be a future source of mercury for ASGM in the region. The statistical data, however, appear to be flawed to an extent that the results cannot be considered reliable. The total mercury content of mercury-added products is described in section 2.2.

### Conclusion

Some liquid mercury may be traded under other commodity codes, but no examples have been identified. Furthermore, it is difficult to identify any incentives for using different codes as mercury may be legally imported in the major import countries. It seems more likely that some additional mercury is informally imported without registration.

## 2.2 Price of mercury through the value chain

The following section analyzes the available data on mercury prices through the mercury value chain in Sub-Saharan Africa. A more detailed description of the actors in the value chain is provided in section 2.3.

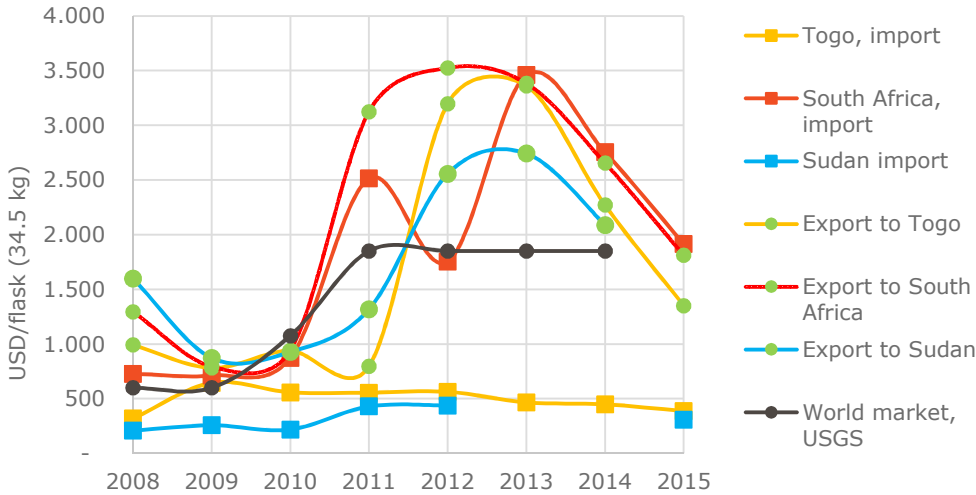
### 2.2.1 International trade

According to the USGS Mineral Yearbook (2016), the world market prices of mercury increased during the

period of 2006 to 2014 from USD 670 to 1,850 per flask, corresponding to an increase in the price from USD 19 to 54 per kg. The major increase occurred during the period 2009 to 2011 while the price was stable during the period of 2011 to 2014.

A closer analysis of the data on traded tonnages and the value of the mercury, however, shows a more dynamic pattern. Figure 2.7 shows the trend in average value of mercury imported to the major import countries Togo, South Africa and Sudan during the period 2008-2015 along with the data from USGS (2016). The import data are represented by both registered import (as registered by the countries) and registered export to the countries (as registered by partner countries). The average price per flask of registered export to the three countries follows the same trend. This trend is similar to the pattern in registered import to South Africa. The prices peaked around 2012-2013 at about USD 3,500/flask. For 2014 the registered price was within the range of USD 2,100-2,800/flask, while for 2015 it was within the range of USD 1,400-2,000/flask. The value of the registered import to Sudan and Togo is much lower, indicating that the import was registered with a value far below the actual value of the import.

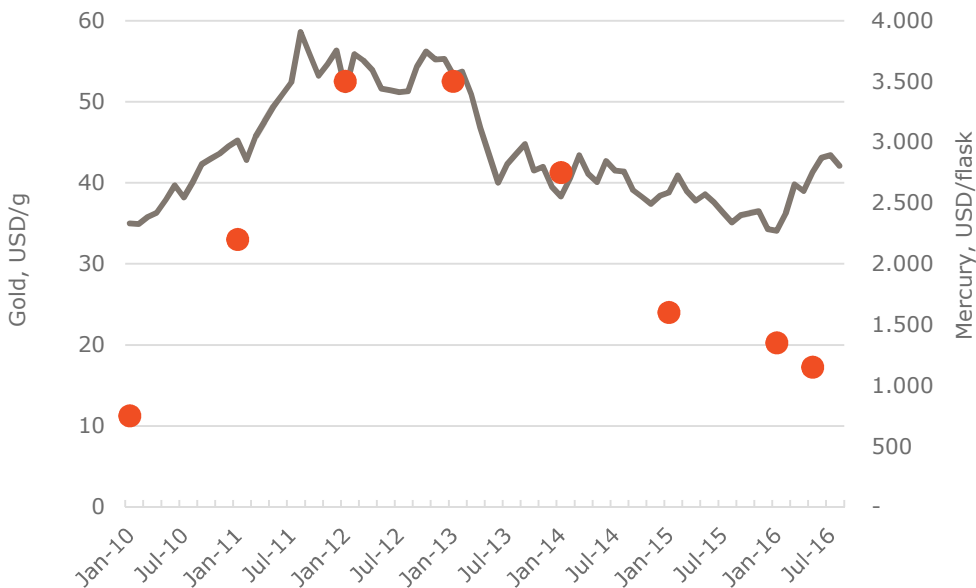
As shown in Table 2.5, the average price of exported mercury in 2015 differs significantly among major global export countries with average prices in the range of USD 459 to 627 per 34.5 kg flask from India, China and Switzerland, and prices in the range of USD 1,093 to 1,926/flask from Japan, Singapore, China Hong Kong SAR and Mexico.



**Figure 2.7**  
Trend in average prices per 34.5 kg flask mercury as registered for import to Togo, Sudan and South Africa as well as prices of registered export to the countries. (Source: Comtrade) World Free Market prices as indicated in Minerals Yearbook from USGS making reference to Platts Metals Week, shown in black.

International trade data are not available for 2016. The figure below shows prices of mercury for shipment of 50-100 flasks (1.7-3.5 tonnes) from a major international mercury dealer as reported by the dealer to Maxson (2016b). The prices for the period 2010 to 2015 correspond well with the prices indicated above based on export data, and the figure shows a downward trend from USD 3,500/flask continuing to a price of approximately USD 1,200/flask in May 2016. This corresponds to a decrease from USD 101/kg to USD 35/kg during this period.

Davis (2014) has demonstrated how the mercury and gold prices during 1980 to 2012 have been closely correlated. Gold prices for the period Jan 2010 to Aug 2016 is shown in Figure 2.8 together with the reported trend in mercury prices. Even some correlation is seen, the mercury prices are much more dynamic and the trends can only to a small degree be explained by the changes in gold prices.



**Figure 2.8**  
**Red bullets:** Price of mercury for shipment of a quantity of 50-100 flasks from a major mercury dealer supplying the world market (country not indicated) (Data provided by Maxson, 2016b)  
**Gray line:** Gold prices from International Gold Council at <http://www.gold.org/investment/interactive-gold-price-chart>. Data indicated to be supplied by BullionDesk.



The price trend for 2013-2015 is confirmed by data from two of the major hubs for the global mercury trade, Singapore and China Hong Kong SAR, as shown in Table 2.10. In accordance with this trend, the average price of mercury exported from Mexico, the second major manufacturer of mercury from primary mining and the major export country, decreased from USD

3,017/flask in 2013 to USD 1,565/flask in 2015 (Source: Comtrade). The table also indicates that some mercury at very low prices is available at the global market (possibly from chlor-alkali plants or other sources of recycled mercury) as the average price of the 78 tonnes imported to Hong Kong in 2015 was only USD 462/flask.

Table 2.10 Average price of mercury imported to and exported from Singapore and Hong Kong 2013-2015 (Source: Comtrade)

Country	Import			Export	
	Year	t/year	USD/flask *	t/year	USD/flask *
Singapore	2013	328	1,986	293	3,497
	2014	113	2,341	112	2,724
	2015	126	964	140	1,587
China Hong Kong SAR	2013	108	3,058	149	3,181
	2014	2	2,676	102	2,768
	2015	78	462	20	1,926

\* Calculated from USD per tonne. One flask = 34.5 kg.

### Explanation for the price drop in recent years

According to Merchant Research and Consulting Ltd <sup>3</sup> which prepared the market report "Mercury: 2015 World Market Review and Forecast": *"The market for mercury is characterized by several peculiar features. Firstly, global mercury commodity market is small in tonnage, value of sales and volume of trade operations, though the raw commodity mercury is extensively traded around the world, often via entangled, complex and uncontrolled routes (in general, mercury trade statistics is hard to follow and rely on). There are few key primary mercury producers on the market and their role is diminishing, but the importance of secondary suppliers and recyclers, who do not depend on mercury production, is rising as by-product and other secondary mercury recovery increases. Secondly, thanks to the environmental and health-driven concerns, global demand for mercury is gradually ebbing (so are output, actual consumption and prices, with no prospects of a reversing trend), and the general market oversupply is vivid."*

Therefore, the market currently appears to be oversupplied with mercury, a situation which will change with

the implementation of the Minamata Convention. As an example of a reaction to the Convention requirements as regards the Japanese non-ferrous industry, which produces by-product mercury from smelting, Reuters <sup>4</sup> reports that *"If Japan's mercury exports are scaled back to virtually nothing as proposed, industries will need to secure disposal sites for tonnes of the poisonous metal in an earthquake-prone country where storing hazardous waste has become an especially fraught issue since the Fukushima nuclear crisis" and "With the chance that storage could be dotted around the country, industry lobbyists say convincing local communities to host disposal sites would be a major challenge in one of the world's most seismically active regions."* Export of mercury is also considered a cheap solution for getting rid of excess mercury.

As discussed above, the demonstrated correlation between mercury and gold prices during 1980 to 2012 has not continued in recent years as the trend in mercury prices have been much more dynamic than the trend in gold prices for the period Jan 2010 to Aug 2016. An explanation for the steep increase in mercury prices from 2010 to 2012 may be explained by the market

<sup>3</sup> <https://mcgroup.co.uk/news/20150623/demand-mercury-fall-application.html>

<sup>4</sup> <http://www.reuters.com/article/us-japan-mercury-ban-idUSKBN0GP1WS20140825>

reacting to an expected shortage in supply due to the export bans in the EU and the USA. From 2013 to 2016 the prices decreased again as no shortages was experienced. Besides increased primary mercury mining in Mexico, there seems to be a tendency in recent years of selling out of mercury e.g. from Switzerland and Japan before entering into force of export bans.

### **Price of mercury provided by major mercury traders in South Africa**

As part of this study, prices of mercury supplied from six major mercury traders/suppliers in South Africa have been collected through interviews of the companies. Import and export of mercury is legal in South Africa but requires a permit. The traders/dealers advertise on the internet and anyone can buy the mercury. The mercury from these suppliers is typically supplied in 34.5 kg flasks. Some of the companies have specifically indicated that they legally export mercury to other countries in the sub-region.

The companies indicate prices ranging from USD 700 to USD 3,500 per flask, corresponding to a range of USD 13-101/kg (when sold by flask). The large price range is surprising, but the prices reflect the ranges indicated above for mercury imported to Singapore and China Hong Kong SAR. Apparently, the price differences do not reflect different qualities.

One major supplier in South Africa stated that the companies advertising very low prices are attempting to scam the customer. According to the supplier, the companies will request that a deposit is made and they will not respond thereafter. The information has not been confirmed by other informants. At least some of the companies appear to be serious traders of various commodities.

The countries of origin are indicated by the trading companies as Algeria, Spain, China, Japan and Egypt.

Of these, official statistics for 2014 and 2015 indicate import from China and Japan, whereas import from Algeria, Spain and Egypt is registered neither by South Africa nor the partner countries. Official data for 2016 are, however, still not available. Two of the companies indicate import from Spain, though export from Spain has been banned for the last five years. This discrepancy may, however, be due to long-term storage within the company. Most of the companies are general trading companies specialized in trade of agricultural products and they may have stocks of mercury. One of the companies e.g. indicated that they have 552 flasks in stock for supply (approx. 19 tonnes mercury). Another company indicated that they can supply 1000 flasks per month (34.5 tonnes) and a third indicated that they received a shipment of 500 flasks (17.3 tonnes) later the same week. If the information is correct, the companies apparently have no difficulty in buying mercury in large quantities on the world market at prices below USD 1000/flask and for two of the companies they are even able to buy it at a price below USD 500/flask. Similar prices have also been identified via the internet from one other trading company in South Africa.

One company indicated that they could provide 600 flasks per year (~21 tonnes) of mercury recovered from South African sources. A possible source of this could be by-product mercury from gold mining. The information on recovery of mercury in South Africa has not been confirmed from other sources. The Chamber of Mines in South Africa has been requested information on the quantity of by-product mercury recovered from the smelting of gold, but no data on mercury recovery or mercury in gold ore mined in South Africa have so far been obtained.

Examples of mercury for sale by South African companies at the trading site <http://south-africa.exportersindia.com> are shown below.

**Table 2.11**

*Price and origin of mercury supplied by six major traders/suppliers of mercury in South Africa, May-June 2016. Information as reported by the importers during telephone interviews*

Type of Company	Price, USD per flask *	Quantity for supply	Origin	Source of mercury	Purity	Delivery with Permits	Regional Trade
Supplier of mercury and other metals	3,120*	"unlimited supply"	Singapore	Unknown	99.99%	No	Unknown
Trading company, mainly agricultural products	700	552 flasks	Algeria Spain China	Chlor-alkali plant (Algeria)	99.9995%	Yes	Yes
Supplier of mercury and other metals	1,075 *	"12 Flask and expecting 510 flasks this week."	Japan	?	99.9%	Unknown	Unknown
Trading company, mainly agricultural products	485 *	"100 flasks with another shipment arriving next week."	Spain	?	99.999%	Yes	Yes. Has traded to Zimbabwe. Biggest customer in Hungary.
Trading company, mainly agricultural products	450 *	1000 flasks per month	Egypt	?	99.9%	Yes. Import and export permit. No indication of special permit for mercury	Unknown
Trading company, agricultural products and metals/minerals	3,500	600 flasks per year (~21 tonnes)	South Africa	Recovered from the South African gold Mines**	99%	Yes. Permits from ITAC & SGS Third party inspection	Yes

\* Converted from South African rand July 2016. Price for purchase of mercury in flasks.

\*\* The information on recovery of mercury in South Africa has not been confirmed from other sources. The Chamber of Mines in South Africa has been requested information on the quantity of by-product mercury recovered from the smelting of gold but no data on mercury recovery or mercury in gold ore mined in South Africa have so far been obtained.



*"We offer prime virgin silver liquid mercury. - packing iron cylinder (34.5 kg net weigh)."*



*"We supply liquid silver mercury in very large quantities and also ensure safe and prompt delivery of goods to your destination. Virgin mercury purity = 99.99% by wt min. Free from heavy metals packing iron cylinder (34.5 kg net weight) or 1 kg flask". Similar flasks have been identified by gold broker in Gaita, Tanzania.*



"We are offering pure metallic mercury. Packed in 34.5 kg flasks."

"We can supply virgin liquid mercury with purity 99.99% in stainless steel flasks of 34.5 kg net. We sell at moderate prices and we ship worldwide." Similar flasks have been identified by small mercury dealers and mining sites in Zimbabwe and Ghana.

### Figure 2.9

Examples of advertising mercury for sale in South Africa by companies with addresses in South Africa at <http://south-africa.exportersindia.com/mineral-metals/mercury.htm>

## 2.2.2 Local and sub-regional trade

As for other commodities, the price of the mercury increases though the value chain.

The analysis of the price changes though the value chain is complicated by the dynamic of prices also on the world market. As indicated above, world market prices for one trading company have decreased from a level of around USD 3,500/flask in 2015 to USD 1,200 in May 2016, and available trade data indicate that mercury from some countries is traded at prices well below USD 1,000/flask. Prices for mercury sold by flask from traders in South Africa in spring 2016 ranged from USD 450 to USD 3,500/flask. The prices appear to be highly dependent on the actual supply/demand situation.

The following is based on information collected by field investigations in the eight participating countries and information provided in the literature. The information consists of many different cases, listed in Table 2.12. The information is summarized in Table 2.12. All prices

have been converted to USD with July 2016 exchange rates.

### Trend in local prices

The decreasing price of mercury on the world market is also reflected in local prices.

An informant in Zimbabwe informs that today a kilo may cost as little as USD 45 in South Africa. During 2010-2011 a kilo would cost as much as USD 300-350.

One informant in Uganda states that on average, a kilogram of mercury has been sold for one million UGX (USD 300/kg), but this has reduced by half to five hundred thousand UGX at the moment (USD 150/kg).

Persaud (2015) reports that on every site he visited in Senegal in 2014, the cost of mercury for a 10 gram plastic bag was between CFA 1,500 - 2,000 (USD 250-340/kg). Data collected in this and a recent study (unpublished) indicate prices in the range of CFA 1,000 - 2,000 (USD 165 - 340/kg).

**Table 2.12**  
Information on prices at different levels in the value chain. Unless specified, the prices are 2016 prices.

Country	Price of mercury
Burkina Faso	According to informants, the mercury sold is sold at a price of CFA 50,000 - 80,000/kg (USD 95 - 145/kg depending on quantity and the actual supply/demand situation).
Côte d'Ivoire	The ASM organization has informed that the mercury is sold to artisanal miners at the price of F CFA 500 for 10 g (corresponds to USD 85/kg). According to other informants, the mercury is sold by suppliers from Burkina Faso at a price of CFA 40,000 to 50,000 per kg (USD 68 to 85/kg). If mercury is bought directly from suppliers in Ghana, the prices are reported to be higher.
DR Congo	In the Kamituga area, the main quantities used by the miners are the spoon and the pen cover. A spoon can be bought for USD 15 – 20 depending on the season (Kamituga is hard to access in the rainy season). The pen cover is sold for USD 5 to 6. Mercury is reported by its users to be bought in Bukavu at the border to Rwanda at USD 300/kg, but many traders have confirmed recently buying it at prices between USD 130 and 200/kg, which is comparable to the prices paid in mining areas of Uganda and Tanzania. Price variations are due to climate conditions related to accessibility, but there are also other factors in play.
Ghana	Mercury is sold in 750 mg beer bottles for GHS 3,000 for 10 kg (USD 78/kg). Measures below this quantity include eardrop and penicillin bottles, often referred to as <i>pohu</i> ; one example of a <i>pohu</i> is a 5 cl bottle (30-50 g) sold for GHS 20-30 (USD 150-250/kg).
Kenya	In three shops visited in Dar es Salaam Street in Nairobi, Kenya, August 2016, the prices of mercury were about KES 3,500/kg (USD 34/kg).
Republic of South Africa	See separate section above.
Senegal	<p>A mercury retailer and local gold buyer at a mining site in Senegal reported for this study that he buys the mercury from unofficial sellers, at a price of CFA 500 per 10 g (USD 83/kg). Mercury is sold in plastic bags, in a fluid state. The mercury is sold to the miners from whom he buys gold. The price for the mercury is CFA 1,000 (USD 165/kg).</p> <p>Socioenvironmental investigations done as part of a recently finished project in Senegal confirm that the mercury is also sold in bags of 10 g, at a price varying from 1.000 to 2.000 CFA (USD 165 - 330/kg).</p> <p>A laboratory &amp; importer company in Dakar informed the study that the price of a bottle of 1 kg of mercury has increased from EUR 100 to EUR 283 (USD 315/kg). It should be noted that this mercury may be of higher quality than the mercury used for ASGM.</p> <p>Persaud (2015) reports that on every site he visited in Senegal in 2014, the cost of mercury for a 10 gram plastic bag was between CFA 1,500 and 2,000 (USD 250-340/kg).</p>
Tanzania	<p>In the urban centers of Mwanza, Arusha and Dar es Salaam, a kilogram of mercury sells for between TZS 250,000 and 300,000 (USD 114-137/kg) (May 2016). The price of mercury in the ASGM areas is approximately TZS 300,000/kg (USD 137/kg), with soda bottle caps containing between 50 and 60 grams of mercury being sold for TZS 30,000 (USD 228-273/kg).</p> <p>One informant states that mercury is purchased from local gold-buyers and mercury middlemen, who sell it at an average price of TZS 450,000/kg (USD 204/kg); the price can soar to TZS 800,000/kg (USD 364/kg) in periods of shortage. Mercury dealers in Northern Tanzania sell full 34.5kg-flasks at an average price of TZS 202,900/kg (USD 92/kg).</p> <p>In 2014, an informant purchased 5 kg of mercury from a supermarket in Dar es Salaam Street, in Nairobi, where mercury is sold in plastic bottles by Indian brokers at a price of TZS 50,000/kg (USD 23/kg). She sold her stock to local ASG miners at a final price of TZS 300,000/kg (USD 137/kg).</p> <p>Fold et al. (2014) report that most of the gold buyers also sell mercury to miners at 40,000 TSH for a soda cap of 50–60 grams (USD 480/kg) or at 470,000 TSH for a kilogram (USD 310/kg) (January 2013).</p>
Uganda	<p>The price of mercury in Uganda was quoted to be UGX 600,000 for a kilogram (200 USD/kg) and UGX 1,000 for a gram (USD 330/kg), though one informant mentioned a price of UGX 2,000 for a gram (USD 670/kg).</p> <p>One informant states that on average, a kilogram of mercury has been sold for one million UGX (USD 300/kg) but this has reduced by half to five hundred thousand UGX at the moment (USD 150/kg).</p> <p>According to the Busia United Small Scale Miners Association, mercury is delivered in the area in bottles (flasks) with labels "Made in India". The price of mercury often depends on supply and 1 kg of mercury ranges between UGX 500,000 and UGX 800,000 (USD 148-238/kg) while one gram is sold for UGX 1,000 (USD 330/kg).</p>
Zimbabwe	<p>In Zimbabwe, one kilogram sells at an average of USD 140/kg. While most informants mentioned this amount, one mentioned USD 100-120/kg and one USD 160/kg. With regard to smaller quantities, the prices vary a great deal; prices between USD 6 and 15 was reported depending on location, relationship etc. (USD 120 - 300/kg).</p> <p>One informant argued that mercury from India is better and more expensive than mercury from China, i.e. 140 USD/kg versus USD 120-130/kg. It was informed by several informants that Chinese dealers sell at lower prices than others.</p> <p>One small trader informed that he buys 34.5 kg flasks for USD 78/kg and sells in one-kg bottles at USD 120/kg</p>

Most information has been collected from users of the mercury (i.e. the miners or miner's organization), whereas limited information is available from the mercury dealers, who are less forthcoming about the prices of the mercury they buy and sell. Furthermore, it is difficult to obtain information from the dealers about the sources of the mercury they sell.

**Example, Zimbabwe** - One example based on the collected information appears to be typical of the local

trade in Zimbabwe, a small trader in 2016 buys flasks (one at a time) in South Africa at a cost of USD 2700/flask (USD 78/kg, see picture below). The mercury is smuggled into Zimbabwe in a trunk of a car and is sold in 1 kg flasks (cough syrup plastic containers) to custom millers at a price of USD 120/kg. The custom millers are reported to have a demand of about 2 kg each per week.

**Photo 1**

Flask of mercury smuggled between South Africa and Zimbabwe in a trunk of a car. The flask was indicated to be from the USA. The mercury is sold in 1-kg bottles to custom millers (Photo: R. Murinda, this project)

**Photo 2**

The only licensed mercury importer in Zimbabwe sells the mercury in plastic bottles of approximately 1 kg. Bottles from this company was the only bottles identified which contained any risk indication (Photo: COWI)

**Photo 3**

The mercury is often sold in old soda plastic bottles as this example from Zimbabwe. Here the mercury is collected for reuse and mixed with water (Photo: COWI)

**Photo 4**

In this example from DR Congo, the mercury was sold in 1-kg container to the miners by local gold buyers (Photo: R. Kitungano, this project)

**Photo 5**

At this mining site in Uganda, the mercury was transported to the site in plastic containers with approximately 1/2 kg mercury and sold to the miners by local gold buyers (Photo: COWI)

**Photo 6**

The 34.5-kg flasks are reused many times. This flask is bought by a small-scale gold mining site in Zimbabwe (Photo: COWI)

**Photo 7**

Mercury flasks (34.5 kg capacity) displayed at a gold broker's workshop in Geita, Tanzania. The flasks were not labelled (Photo: COWI)

**Photo 8**

Bottle that typically is sold containing up to 1 kilo of mercury in Geita, Tanzania (Photo: COWI)

**Photo 9**

A seal bag sold to miners in Zimbabwe with approximately 30 g mercury (Photo: COWI)

**Example, Tanzania** - The general pattern appears to be that the mercury dealers buy 34.5 kg flasks in Nairobi and bring it to the mining fields in Northern Tanzania where it is divided into smaller quantities: either 1-2 kg flasks or small caps of 50-60 gram. The mercury, however, may also be imported to the mining areas in smaller quantities. In 2014, an informant purchased 5 kg of mercury from a supermarket in Dar es Salaam Street in Nairobi, where mercury was sold in plastic bottles by Indian brokers at a price of TZS 50,000 (USD 23) per kilogram. The mercury was sold to local ASG miners in Northern Tanzania at a final price of TZS 300,000 (USD 137) per kilogram.

**Example, Senegal** - A mercury retailer and local gold buyer at a mining site in Senegal reported for this study that he buys the mercury from unofficial sellers at a price of CFA 500 per 10 g (USD 83 /kg). Mercury is sold in plastic bags, in a fluid state. The mercury is sold to the miners from whom he buys gold. The mercury has a price of 1,000 FCFA (USD 165 /kg).

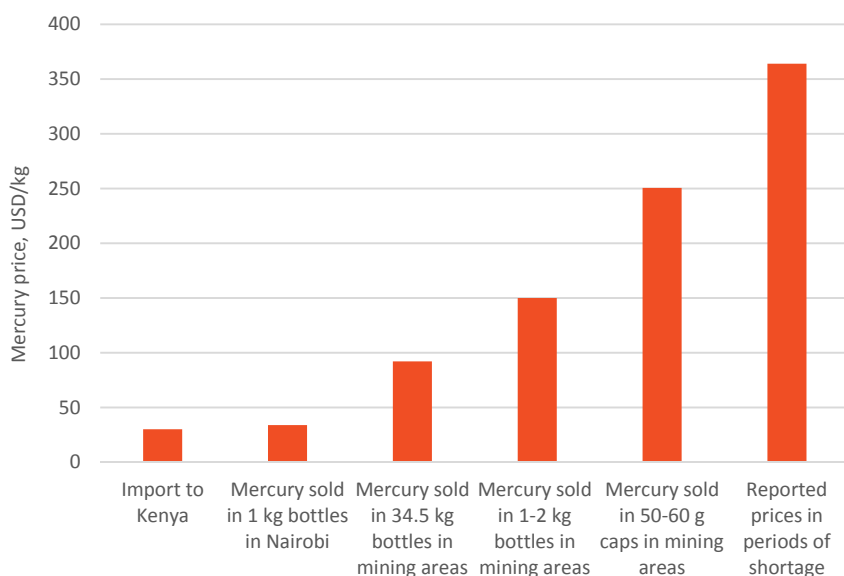
The prices at the different steps in the value chain appear similar in the countries; however, the price level in Ghana is currently lower than in the other countries. As shown in Figure 2.7, the average value of mercury exported to the main import countries Togo, South Africa

and Sudan are similar and follow similar trends over time.

The overall pattern is that the mercury is imported in shipments of 50-100 flasks at prices reflecting the current prices in the main mercury exporting countries. The mercury is sold in flasks (one or several) and transported to the mining sites where it is either sold in flasks to dealers (who sell it to the miners), in 1-2 kg containers to amalgamation/milling centers or gold dealers (who sell it to the miners) or in small 10-60 g plastic (or even smaller) flasks or bags to the miners.

The prices generally follow the quantities as illustrated in Figure 2.10, showing average price data from mining areas in Northern Tanzania imported via Nairobi in Kenya. In the absence of data from importers in Kenya, the price of mercury purchased directly from importers is based on the case story from Zimbabwe. Prices reported from the mining areas in other countries in Eastern Africa are quite similar to the prices reported from Tanzania.

However, as illustrated with the data from importers in South Africa, with prices ranging from USD 450 to USD 3500 per flask (USD 18-142/kg) the reality is more complex than illustrated by the figure.



**Figure 2.10**

*Development in price of mercury through the value chain in Kenya and mining areas in Northern Tanzania, June-August 2016. The average price of mercury exported to Kenya in 2015 was USD 54/kg as reported by partner countries, but this is based on data on the world market price trend from 2015 to 2016. Prices of mercury sold in Nairobi in August 2016 indicates that the average price of imported mercury in spring 2016 likely was no more than USD 30/kg. In three shops in Nairobi, August 2016, mercury was sold in 1-kg bottles at about USD 34/kg.*



## Total revenue

With an estimated mercury trade of 200-400 tonnes and a revenue through the value chain of approximately USD 150-200/kg, the total revenue of the mercury trade in Sub-Saharan Africa in 2015 can be estimated at USD 30-80 million. If this revenue is compared to a typical Sub-Saharan African income of USD 3,000/year, it corresponds to the income of 10,000 - 27,000 people.

## Changes in prices

Limited information on recent trends in prices has been obtained from the field investigations. One informant in Uganda stated that on average, the price of one kilogram of mercury in the mining areas has reduced by half, from USD 300/kg to USD 150/kg, reflecting the observed decrease in the world market prices.

In Geita in Northern Tanzania, the prices for 1 kg mercury increased from approximately USD 55/kg in November-December 2010 to USD 115/kg in November 2011 (Jönsson, personal observations). This increase reflected the steep increases in the world market prices between 2010 and 2011. The price today is closer to the prices reported from 2011.

## Mercury shortages

In general, mercury is readily available on mining sites in all of these countries. One small-scale miners association in Uganda, however, stated that the gold miners in the area have access to mercury all the time, although some mercury scarcity is experienced during June to December. During this period, the miners always prepare themselves by stocking enough mercury. It was further indicated by some informants that during mercury shortages, the prices may increase.

## 2.3 Actors in the mercury supply chain

The supply chain of mercury has many different actors and the type of suppliers; these may be different from site to site and between regions. The main supply chains are illustrated in Figure 2.11, but the supply chains are more diverse than illustrated.

Like with the value chain of gold, the supply chain of mercury should be seen as a triangle with some major sellers on top and a large network of increasingly smaller suppliers as you move down in the triangle.

Even though mercury trade and use in ASGM are fully legal in many countries, in all countries mercury is a "hidden" commodity. As indicated by one ASM organi-

zation: *"The main reason why mercury is smuggled is because it is a highly sensitive metal. The moment you say "mercury", the officials will call in radiation specialists, etc. and the importation process becomes lengthy"*. Mercury is not visible on the shelf of small gold shops, pharmacies and mining equipment shops in the ASGM areas, but it is possible to buy mercury in the shops. However, often an introduction is necessary in order to be able to buy the mercury. For a person just stepping in from the street the message is often that mercury is not sold. In all eight countries, mercury is available in the ASGM areas, although in some areas some shortages have occurred, with resulting higher prices, at different points in time.

**Importers of mercury to the region** - Mercury is legally and officially imported to the Sub-Saharan region by trading companies specialized in import of commodities. As part of the study a number of importing companies in South Africa, where trading companies legally import and trade large quantities of mercury, have been contacted (see

Table 2.11). The listed importers include companies specialized in trading of mercury and other metals, and general trading companies which import/export various commodities, in particular agricultural commodities. The list is not comprehensive and mercury is known to be traded by companies providing equipment for the mining sector as well. Many of the companies advertise on the internet and can be identified through trading databases.

In Ghana, 18 mercury shipments by licensed companies were recorded by the licensing authority during the period 2011-2016. The data demonstrate that many different companies are involved in the formal import of mercury. Each company has reported one shipment only, i.e. import is not undertaken by a few companies with a frequent import of mercury. This clearly indicates that the mercury is not imported and further distributed by well-established formal channels. The recorded shipments ranged from 2 flasks (69 kg) to 20 tonnes, and the total was well in accordance with the annual import data registered in the Comtrade database. The registered import of mercury, however, is far below the total estimated mercury consumption for ASGM in the country. The mercury was imported by many different types of companies: a supplier of chemicals, a supplier of mining equipment, a gold mining company, general trading companies (wood, agricultural products, etc.), and a gemstone trading company. Each company has reported one shipment only; the import may in fact be organized by actors more specialized in mercury trade, as indicated in field interviews. As the traded quantities of mercury amount to less than one container, it is likely that the traders organize the import with companies with empty space in shipping containers. It has not been possible on the basis of the company names to contact any of the companies.

Data on the official import to Senegal from 2005-2015 show that permits during this period have been obtained for 7 shipments by 6 different companies. The quantities ranged from 3 to 367 kg per shipment. The importing companies were mainly companies in the dental and health sector (judged from names of the companies). The last shipment with permit was in 2011. For 2010 and 2011, the quantities are well above the expected quantities for dental applications and a part of the mercury may in fact have been used in ASGM. One former employee of a mechanized small-scale mining company has informed that the company purchased mercury in a laboratory in Dakar. Various anecdotal

information from more than one country mention that some mercury from the dental sector is directed to ASGM. Considering the relatively small official flows of mercury, it is estimated that officially imported mercury for dental applications directed to ASGM would account for a small part of the total consumption of mercury for ASGM.

In other major import countries such as Togo and Kenya, it not been possible to identify the main importers via the Internet, but it is expected that the official import is undertaken by various trading companies (as is the situation in Ghana and South Africa).

**Informal import to the region** - As indicated elsewhere, the officially registered import of liquid mercury to the region appears to be somewhat lower than the estimated consumption for ASGM; in particular in Western Africa. The available data indicates some informal import from countries outside the region, but informal import is by nature difficult to track. Anecdotal information indicates that in some countries, mercury is imported informally together with mining equipment from China, but it has not been possible to confirm this information.

**Importers of mercury within the region** - The majority of trade between the countries in the region is informal and the mercury is smuggled across porous borders. In a few instances, official import from another country in the region takes place; this mainly concerns import to Zimbabwe from South Africa.

In Zimbabwe only one company is currently licensed for import of mercury, but the total formal mercury import is far below the actual consumption in the country. Before introduction of the license system, mercury was formally imported from South Africa by a number of registered mercury dealers. These companies were mainly importers of mining chemicals and equipment and trading companies importing products for various industrial sectors. As a result of the licensing system, the official import has decreased markedly. The official import as registered in the UN Comtrade database was 10.4 and 17.9 tonnes in 2011 and 2012, respectively, but decreased to 94 kg in 2014 and 9 kg in 2015. This example illustrates the difficulties in controlling mercury import.

**Gold traders** – Aspects of the mercury trade are closely linked to the gold trade. In many of the countries both mercury and gold trade is characterized by informal

networks and it is difficult to obtain information on the supply chains. In Eastern Africa, Indian companies are heavily involved in both mercury and gold trade. In Western Africa traders from Burkina Faso seems to play a major role in both chains. The step whereby the mercury is supplied to the miners is relatively well described. In many cases the mercury is supplied for free or at low prices to the miners in exchange for gold or on credit subject to the miners selling their gold to the gold buyer at a price where the mercury cost is deducted. However, it is also common that the mercury is sold by small gold buyers in the mining sites at market prices. The mercury supplied to the small local gold buyers may be supplied from the gold traders who buy the gold from the small gold buyers, or it may be supplied by small specialized mercury traders. Larger gold buyers in cities as Nairobi and Dar es Salaam also sells mercury to small mercury traders not involved in the gold trade. From field investigations it was noted, that the gold buyers do not sell the mercury to customers just coming in from the street and it is necessary to be introduced by people trusted in the community. This has also been informed by small mercury traders who has described how they were introduced to the community.

**Small mercury traders** - Many examples exist of small mercury traders who supply mercury in small quantities down to 10 g to the miners. The traders typically buy one or a few flasks, but sometime only a few kg, from mercury trading companies in the towns and transport the mercury to the ASGM areas. In the case that the mercury is transported across borders, the mercury will be smuggled in private cars, vans, buses, bikes, motor-bikes, etc. The majority of trade across the borders in the region is expected to be undertaken by the small mercury traders or by actors in the gold value chain.

**Financiers / claim owners / custom millers / large-scale gold producers** - The mercury is often supplied to artisanal miners by the larger actors in the ASGM sector. In many cases, the mercury is supplied by the financiers or claim owners to the miners working on the claim. Large customs millers (e.g. in Zimbabwe) and large-scale gold producers are reported to supply or sell mercury to artisanal miners in exchange for gold.

**Shops selling mining equipment** - In many ASGM areas, mercury is sold in shops selling mining equipment. To some extent, the mercury appears to be supplied to these shops along with other mining equipment by importers/traders of mining equipment.

**Medical sector and laboratories** - In several of the countries, informants have stated that mercury is sold in pharmacies, laboratories and hospitals. Pharmacies in the ASGM areas typically sell mercury to miners. The supply from actors in the medical sector appears to be small compared to the supply by small mercury traders. In some countries, mercury use for dental applications is allowed while the use for ASGM is prohibited, and it may be expected that the majority of the mercury was traded as being used for medical applications. However, this may not necessarily be the situation, as illegal mercury for ASGM use is available everywhere, usually without shortages in supply.

**Military** - It has been noted in one of the countries that the military uses mercury for certain applications and is involved in trade of mercury, but for confidentiality reasons this part of the trade pattern has not been further investigated.

**Example - case story from Tanzania** - The following case study illustrates how small mercury dealers operate in Tanzania. The informant is a small scale miner who started mining tanzanite in Northern Tanzania in 2007. From 2009 to 2015 he was involved in small scale gold mining activities in a number of gold mines in Northern Tanzania. He started his mercury selling business in 2011 with his partner with a total capital of TZS 3 million (USD 1,370). At that time the price was TZS 380,000 per 1 kg of mercury (USD 170/kg). His partner was responsible for buying the mercury from the wholesalers or suppliers in Mwanza city, and transporting it to the mining town (name kept secret), which was the center of mercury distribution to all surrounding small scale gold mining sites. They were allowed to buy a minimum of 1 kg of mercury from suppliers in Mwanza, which was packed in special medical containers, and whenever they bought they had to check the weight in a scale located at the point of sale. According to the informant, the mercury middlemen would never sell mercury to an unfamiliar person. To be able to buy the mercury, you needed to be personally introduced to the mercury dealer by a known insider. If they were satisfied beyond doubt that you were a genuine buyer, you were able to buy the minimum of 1 kg of mercury. He related that the mercury chain began from Nairobi, the mercury was transported to Sirari border town, then transported to Mwanza and finally, transported to the small mining town. All the dealers knew that the mercury passed through Kenya but did not know the origin or the main supplier in Kenya. The informant sold his mer-

cury mainly in some of the mining sites where the demand was high because the gold mining process in those mining sites was large and more developed with large gold washing sites. He could also sell in other areas especially where there was a gold rush because the profit margins were high due to high demand and low supply. In 2013, there were only four mercury dealers in the small mining town which could supply mercury to small scale mining sites in the surrounding areas. All the dealers knew each other and could share information regarding the business. The mercury business was done in a highly secretive manner because it was illegal; as mentioned by the informant, "an outsider

could only spot mercury physically in the gold processing site". The informant described the challenges of the business such as the availability of mercury, transportation to the site, and safety and security issues because the business was illegal with constant police surveillance. Another challenge was the quality, because it was possible to buy mercury which was "boiled" and functioned less [note: the meaning of this is not clear]. The informant quit the business because his partner was sold fake mercury in Mwanza from fraud dealers with police connections. As a result, his partner was arrested in Mwanza and all the invested capital was lost.

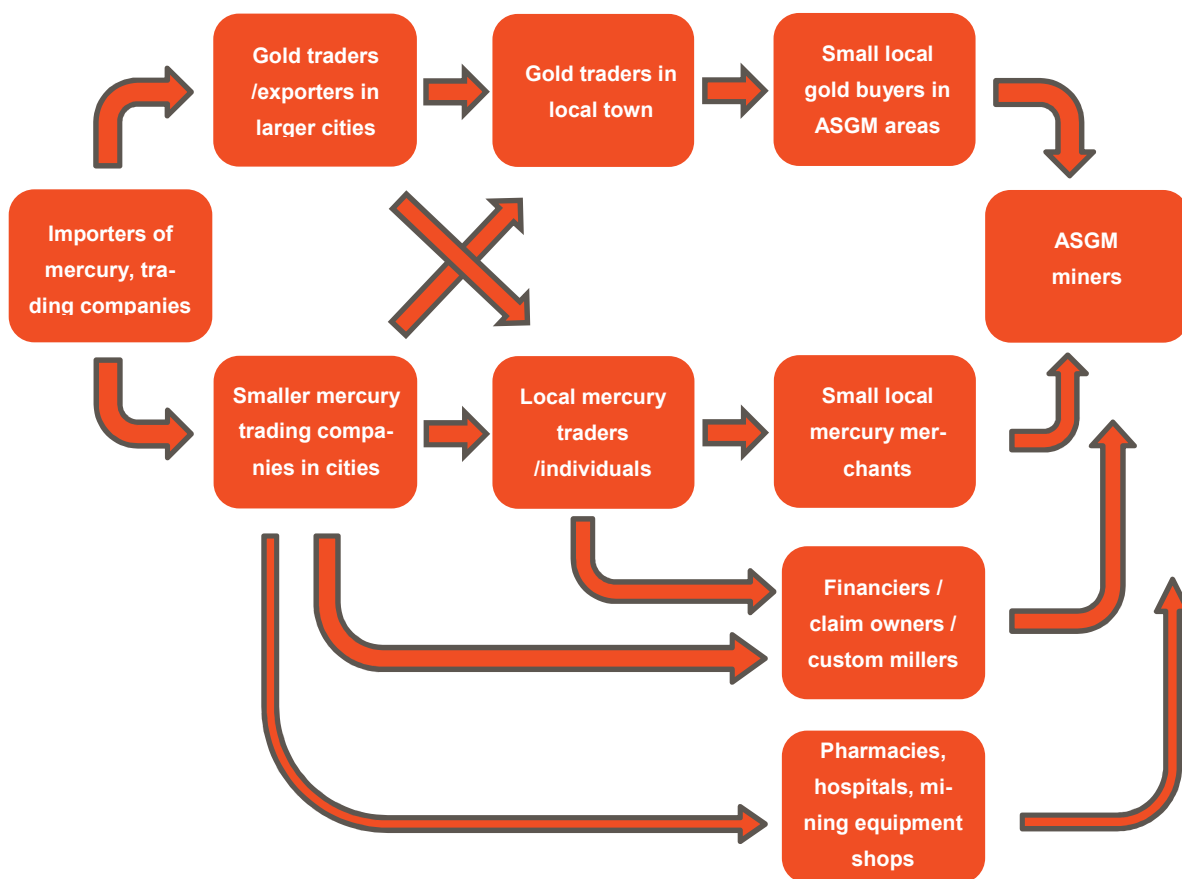


Figure 2.11  
Main mercury supply chains. The figure illustrates the overall pattern, but many exemptions exist where e.g. miners buy the mercury directly from companies/traders higher upstream in the supply chain. Two cross over between the supply chains are indicated, but in reality mercury may be exchanged between the chains at any step.

The table below includes some of the information obtained by field investigations in the participating countries and some information from the literature.

**Table 2.13**

*Information on actors in the mercury supply chain obtained mainly through field interviews of stakeholders*

Country	Information on actors in mercury value chain
Côte d'Ivoire	<p>A site owner in Northern Côte d'Ivoire informed that the supply of mercury to the ASGM site is organized by the site owner, the gold buyers and their supplier based in Burkina Faso. These suppliers have their wholesaler in Ghana. The ASGM site's owner is not allowed to purchase mercury from the wholesaler in Ghana. Even when he tries to find other mercury suppliers in Ghana, the cost of mercury is increased of 60%.</p> <p>Generally, it is the financier who supplies miners with mercury.</p> <p>Sometimes, large-scale miners supply artisanal miners with mercury in order to purchase their gold production.</p> <p>Trafficking of liquid mercury on the black market exists for dentists who are working in the country. This is difficult to track because no one knows the main organizer of that trade.</p>
DR Congo	<p>In mining sites in South Kivu, mercury is sold by gold traders. These traders provide it to individual miners for whom they act as 'sponsors'. The deal is that the trader provides the miner with some credit, including working tools, batteries for torches, equipment, mercury and so on, while the miner comes to sell his produce at the trader's. Traders buy the mercury in Bukavu. Some of them reported to have recently bought it in Kamituga from unknown traders. Small traders in mining sites are tied to larger traders in the provincial capital in the same way as miners are tied to small traders: through chains of credit and debt relations (Geenen, 2015).</p>
Ghana	<p>Allegedly, mercury is imported by business people specializing in the trade. They sell it in Accra or Kumasi to other traders, gold buyers or other types of ASGM investors, all of whom use it to supply smaller buyers or miners.</p> <p>As an example, a small gold buyer informed the study that he buys gold and sells mercury. He buys the mercury from larger gold buyers in adjacent towns for 30 Ghana Cedis; the quantity is equivalent to a tablespoon. He buys pre-packed parcels in small plastic bags. He does not take a profit as the mercury is used to attract customers, i.e. people selling their gold. He knows that the people he buys from buy for 25 Ghana Cedis and thus make five Ghana Cedis' profit on the parcels. The people he buys from typically buy the mercury in Akwatia. In Akwatia, the mercury comes from Accra.</p>
Mali	<p>In a study in the Kangaba Circle in Mali, 20 ASGM miners were asked how they get the mercury. Eight answered that they got it from street vendors who came from the capital Bamako; one bought it on the local market, four from other sources (not indicated) and seven did not answer (FDS, 2010).</p>
Kenya	<p>A study of mining areas in the Migori County close to the border to Tanzania "established that most of materials used to support the industry are smuggled to the region by controlled cartels. Mercury for instance is sold through chemists and by cartels within the surrounding towns and remains a closely guarded secret only known to those who deal in its trade. National Environment Management Authority (NEMA), Kenya's national public environmental watchdog underscores that mercury is a controlled substance that is not allowed to be sold over the counter in Kenya. This therefore points to the fact that mercury is illegally traded in the area without compliance to existing regulations on the use of controlled substances." (CEJAD, 2015)</p>
Mozambique	<p>In a project in the Manica District of Mozambique it is reported that the mercury is either obtained from small mercury sellers or, more commonly, is supplied by the gold buyers who offer the miners a production agreement whereby the mercury is provided for free by the private buyers but, in exchange, the miners have to sell the gold to the private buyers.</p> <p>Data collected in Zimbabwe indicates that Zimbabwean gold buyers sell mercury in Mozambique by crossing their eastern border.</p>
Senegal	<p>Women artisanal miners inform the study that there are two ways of obtaining mercury:</p> <ul style="list-style-type: none"> <li>› 1) through the buyer who provides it and reduces the price corresponding to mercury used when buying the gold,</li> <li>› 2) through mercury sellers who practice door-to-door selling advising they have some "product" for sale.</li> </ul> <p>The miners do not know of any Senegalese selling mercury, only Guinean and Malian. The door-to-door sellers would only sell mercury and nothing else.</p> <p>A gold buyer on an ASGM site informed the study that it is a hidden trade; there are no consistent sellers and no certainty about when next arrival will be. The buyer says people selling mercury are not trading for other items like food, materials, etc. but he is not aware of who they are, some of them speak wolof (Senegalese or Gambian), other malinké (Malian). Sometimes, it is not possible to get mercury for 2 or 3 months.</p>
South Africa	<p>The majority of companies legally importing and trading mercury are general trading companies that buy and sell a diverse range of foods, commodities and goods in the SADC region.</p>
Tanzania	<p>According to informants, most mercury supply to Tanzania's northern regions including the Lake Victoria gold fields and Arusha come from Nairobi, Kenya. It is likely that the mercury enters Tanzania through the border posts of Namanga and Isebania. Mercury enters in one-kg bottles and 34.5-kg canisters and is subsequently divided into smaller packages. The supply chain of mercury from Kenya appears to involve both people specializing in mercury trade and large-scale gold buyers of Nairobi, often jewelry shops, which allegedly also constitute the key buyers of gold from ASGM. Gold buyers upstream are supplied with mercury, which they supply to miners, often on credit, in order to ensure that the miners sell the gold to them.</p>

Country	Information on actors in mercury value chain
	<p>In the southern gold regions of Tanzania including Tanga, Morogoro, Ruvuma and Mbeya, mercury seems to be supplied predominantly from Dar es Salaam with mercury likely to enter the country through Dar es Salaam Port. As in Nairobi, there are accounts that it is the main goldsmiths who is both responsible for buying gold from ASGM and supplying mercury; gold smiths based in and around Indira Ghandi Street were mentioned by several informants.</p> <p>In many of the informant interviews, people stated that mercury is sold in shops selling mining equipment (Mwanza), pharmacies and laboratories (Dar es Salaam) and hospitals (Chunya, Shinyanga).</p> <p>Gold buyers often provide miners with a number of services such as smelting the gold with borax and cleaning it with nitric acid. Upstream in the ASM settlements gold buyers commonly sell mercury to miners. Even though the miners have to pay for these services, the buyers' income from the sale is usually of minor significance in comparison to their total revenue (Fold et al. 2014).</p>
Uganda	<p>Importers and smugglers are likely to consist of a diverse group of small-scale business people and gold buyers, predominantly of Tanzanian, Kenyan, and Congolese origins, according to informants.</p> <p>According to an informant from the Uganda National Artisanal and Small-Scale Miners Association, most traders, of predominantly Kenyan origin, deliver mercury directly to mine sites, although the mercury is as readily available in Kampala. Uganda has also been reported to be a transit country for an informal mercury trade route feeding into the Democratic Republic of Congo (DR Congo).</p> <p>By another account, some ASG miners claim that suppliers are gold buyers of Indian origin, who in some instances trade mercury in exchange for gold.</p> <p>One claim owner related that some Chinese companies smuggle in the mercury together with mining equipment, concealing the mercury in cavities in the equipment. Some of the mercury smuggled into Uganda simply passes through the country on its way to DRC.</p>
Zimbabwe	<p>There appear to be different types of mercury traders:</p> <ul style="list-style-type: none"> <li>› Small-scale business people, who purchase a few kilograms in South Africa or Zimbabwe and sell it on, often in smaller quantities, with a profit.</li> <li>› Gold buyers, who sell their gold in South Africa and bring back mercury, which they sell to miners, often on credit subject to the miners selling their gold to them at a price where the mercury cost is deducted.</li> <li>› Large-scale sellers, who import several hundred kilograms a month and have their own distribution networks.</li> </ul> <p>Mercury is readily available throughout the country, especially in towns and settlements close to the mining activities. It is sold in shops selling mining equipment, pharmacies, and by gold buyers and custom millers.</p>
Sub-Saharan Africa	<p>At the Second Global Forum on Artisanal and Small Scale Gold Mining, UNEP (2013b) countries were asked how the miners get access to mercury. In general the countries from Sub-Saharan Africa (Ghana, Senegal, Sudan, Tanzania, Mali, Burkina Faso, and DR Congo) answered that the miners obtained the mercury from gold traders, gold shops, mine owners, and individual vendors and/or importers. They further noted that much mercury entered the countries as illegal imports through porous borders.</p>

### 2.3.1 Link between mercury value chain an value chain for gold

As indicated by various information sources, seven of the participating countries reported a close link between the value chain for mercury and the value chain for gold, in particular at the ASGM sites.

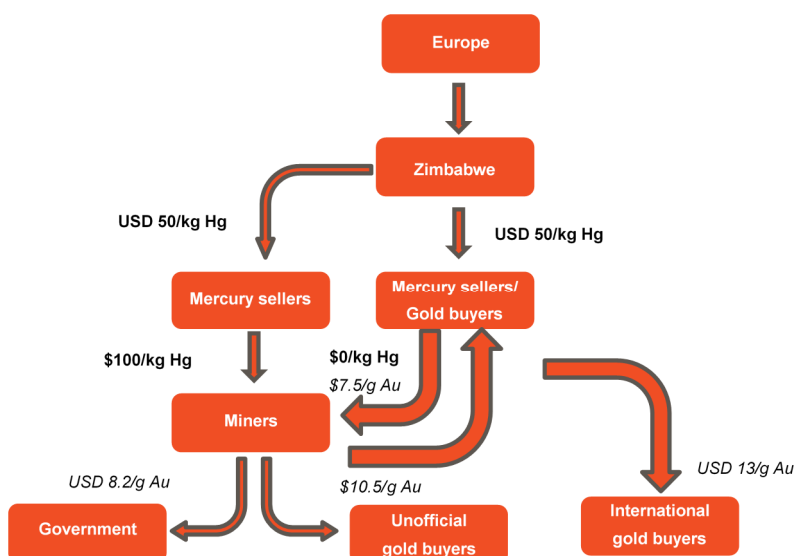
The following description of the steps in gold supply chain is derived from Telmer (2011). Small informal gold shops are common in artisanal and small scale mining communities. After the miners, they are the next link downstream in the informal gold supply chain. They process raw gold or gold-mercury amalgam and then buy the raw gold product from miners at a price that is typically based on the London fix. This price is well known by both the miners and the shop owners because of mobile phones. Some shop owners will also refine the gold to close to 24 k purity (>99%) before

selling it to the next level up in the supply chain. This is often done using the quartering technique, involving creating an alloy with silver and then digestion in nitric acid to separate the gold from impurities such as copper. Others will assess the gold content (often by the difference of weight-in-water and weight-in-air) and then sell the raw product (gold doré) based on its percentage of gold. Gold from shops moves downstream in the supply chain to regional buyers and financiers and eventually to an international dealer and into the international market as jewelry or bullion.

Whereas the link between the mercury and the gold value chain is well described at the level where the small informal gold shops supply the miners, only anecdotal information that actors downstream in the gold value chains supply the small gold shops with mercury, has been available.

The link between the value chains has been well described in a study in the Manica district in Mozambique (Veiga et al., 2005). It was observed that miners had two options for obtaining mercury. The first option was to purchase mercury for USD 2 per 22g (~ USD 100/kg). The 22 g corresponded to the amount of mercury in a water bottle cap. The second option was to deal with the gold buyers. These buyers offered the miners a production agreement whereby the mercury was provided for free by the private buyers but, in ex-

change, the miners had to sell the gold for USD 7.5/g to the private buyers instead of selling for USD 8.2/g to the government buyers. Most of the miners in the area obtained mercury from the private gold buyers, as they did not have the option to purchase mercury from alternative sources. The value chains of mercury and gold are illustrated in the figure below. The increases in the prices of mercury through the value chain are similar to the increases reported in the current study.

**Figure 2.12**

Flow of mercury and gold to Munhena Mine in the Manica district in Mozambique (based on Veiga et al., 2005).

## 2.4 Trade routes

The official statistics provide limited information about the trade between the countries in Sub-Saharan Africa, apart from some reported trade between South Africa and countries in Southern Africa. In the period 2014-2015 the registered export from South Africa included export to Botswana (total 87 kg), DR Congo (11 kg), Mozambique (60 kg), Tanzania (11 kg), Namibia (154 kg), Swaziland (3 kg), Zambia (90 kg) and Zimbabwe (1,359 kg). In total, the registered export for the two years was 1,775 kg, whereas the actual export is estimated to be many times higher.

Most trade between the countries is informal. As described elsewhere the mercury is typically transported in small quantities of one or a few flasks in cars, trucks, buses, bikes, motorbikes, etc. In order to trace the informal trade routes, information has been obtained from miners and organizations in the mining areas and the capitals of the eight participating countries. Examples of

the collected information are listed in Table 2.14. A map with a summary of the overall trade routes is presented in the Summary (Figure 0.5).

In Eastern and Southern Africa, the information on trade routes is well in accordance with the official statistics, indicating that the major entry hubs for mercury are Kenya and South Africa, from which the mercury is distributed to Eastern and Southern Africa. Some Zimbabweans have specialized in the trade from South Africa and also transport and sell to Tanzanians, while some Tanzanians also come to Zimbabwe to buy and bring back to Tanzania. This trade may have grown after several Zimbabweans work in Tanzania setting up or running cyanidation plants for Tanzanians.

In Western Africa trade statistics indicate Togo as a major hub and that the country has been this for many years. The free port in Lomé in Togo is a hub for import of many commodities to Ghana, not only mercury.

Table 2.14

Collected information on cross-border trade routes obtained mainly through field interviews of stakeholders

Country	
Burkina Faso	<p>From several interviews of organizations and individual miners it was informed that mercury was mainly smuggled in to Burkina Faso from Ghana and Togo</p> <p>The mercury is further smuggle to mining sites in Côte d'Ivoire and all informants from Northern Côte d'Ivoire informed that the mercury originated from Burkina Faso.</p> <p>The study was informed that the customs department frequently captures bottles with mercury being smuggled on buses traveling to Burkina Faso from neighboring countries, mainly Togo. If the smuggler was captured he would be sent back to Togo with the mercury. If, however, the smuggler escaped, then the captured mercury was sold on auction by customs office to legal mercury dealers [Note: from other information sources it was informed that no licenses for legal mercury trade was issued].</p>
Côte d'Ivoire	The President of UNOMICI (National Union of Mining Operators in Côte d'Ivoire), carried out investigations in different



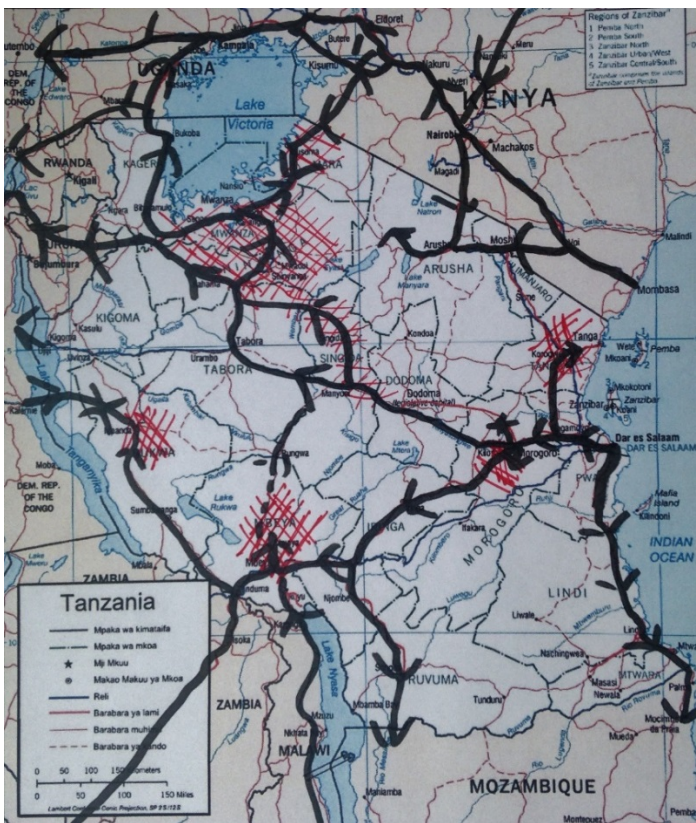
Country	
	<p>artisanal mining sites in 2014. The identified routes of mercury entering in Côte d'Ivoire were:</p> <ul style="list-style-type: none"> <li>› In Northern region: mercury stems from Burkina Faso and Mali</li> <li>› In Western region: mercury stems from Guinea</li> <li>› In Centre – North region: mercury stems from Mali and Burkina Faso.</li> </ul> <p>In a survey carried out by Dominique Bally Kpokro from the NGO Jeunes Volontaires pour l'Environnement, in 2013, it was shown that in some regions of Côte d'Ivoire, mercury routes are the following:</p> <ul style="list-style-type: none"> <li>› In the Central region: mercury come from Burkina Faso,</li> <li>› In Centre-West region: mercury come from Burkina Faso and Mali.</li> </ul> <p>It has been confirmed in this study that a major part of the mercury used in Côte d'Ivoire comes from Ghana and Togo through Burkina Faso.</p> <p>Notably, the mercury does not appear to be imported from Ghana/Togo or directly imported to Côte d'Ivoire (confirmed by official trade data which do not indicate import from countries outside the region). The total quantities of mercury used in Côte d'Ivoire are small compared to the neighboring countries Ghana and Burkina Faso; this trade thus has limited influence on the overall trade pattern in the sub-region. As explained elsewhere, there is historically a link between miners and gold traders from Burkina Faso living Ghana and miners and gold dealers in Burkina Faso, and people from Burkina Faso are involved in the mercury trade in major parts of Western Africa. Mercury-based ASGM was introduced relatively late; mainly by miners from neighboring countries.</p>
DR Congo	<p>All informants agreed that the ASGM sector is highly informal; gold is smuggled out of the country and mercury is likely to be smuggled in. The country has borders with nine other countries and many of the borders are known to be porous. All available information indicates that mercury is coming to South-Kivu from East and there is no indication of any local production of mercury in DR Congo</p> <p>According to informants, since 2012 mercury has been coming to South Kivu from Tanzania to Uvira on the shores of Lake Tanganyika (second major city of the South-Kivu province, close to the borders of Burundi). From Uvira it is transported to Bukavu, the capital and biggest city of South-Kivu province, situated on the shore of Lake Kivu. From Bukavu it is then transported to the various mining sites inland.</p> <p>One informant stated that traders from East Africa (Uganda, Kenya, Tanzania and Burundi), collaborate with Congolese traders in this informal market to sell the mercury.</p> <p>According to one informant, mercury comes from the following countries: Countries like Tanzania, Burundi and Kenya provide mercury in the provinces of South Kivu, Maniema and Katanga; Uganda refuels the Eastern Province. Those who practice this trade are most Muslims..</p>
Ghana	<p>There are different accounts of where the mercury enters Ghana. While most informants indicate the Port of Tema, close to Accra, others mention the porous borders to Togo, Burkina Faso and, to a lesser extent, Côte d'Ivoire. Allegedly, mercury is imported by business people specializing in the trade. They sell it in Accra or Kumasi to other traders, gold buyers or other types of ASGM investors, all of whom use it to supply smaller buyers or miners.</p> <p>From neighboring countries it is informed that mercury is imported to Burkina Faso from Ghana and further transported to Côte d'Ivoire and possibly Mali.</p>
Kenya	<p>Informants in the ASGM areas of Northern Tanzania and Uganda informed the study that the majority of the mercury used comes from Nairobi.</p> <p>Export of mercury by Kenya for ASGM in neighboring countries is not a new phenomenon. Groundwork (2010) noted in a report on mercury flows in the Southern African Development Community (SADC) region: "<i>In 2005, Kenya imported almost 14 tonnes of mercury from Germany, 9.5 tonnes from Georgia and 4.1 tonnes from Japan. Evidence suggests that most of Kenya's imported mercury was then – and still is –exported, legally and illegally, to Tanzania, Uganda and the DRC, where it is primarily used in ASGM.</i>"</p>
Republic of South Africa	<p>Six companies trading mercury in flasks and in large quantities informed the study that the mercury is imported from Singapore, Algeria, Spain, China, Japan, Spain and Egypt. At least four of the companies have all the necessary permits for delivery within South Africa or within the SADC region including Zimbabwe. One company reported export to Hungary (not confirmed by official statistics).</p>
Senegal	<p>For this study informants have reported that the mercury comes from Mali.</p> <p>According to Persaud (2015) mercury is likely entering Senegal through clandestine supply chains, typically by gold buyers entering mainly from Mali, with whom it is believed that the majority of the gold is exiting.</p> <p>The Ministry of Environment assumes that all entrance of illegal chemicals is made through Senegal's eastern and southern "porous frontiers", with Mali specifically, and brought in illegally by Malians and Burkinabe.</p> <p>The information confirms official trade data which do not indicate direct import from countries outside the region.</p>
Tanzania	<p>According to informants, most mercury supply to Tanzania's northern regions including the Lake Victoria gold fields come from Nairobi, Kenya. It is likely to enter Tanzania through the border posts of Namanga and Isebania.</p> <p>In the southern gold regions of Tanzania including Tanga, Morogoro, Ruvuma and Mbeya, mercury appears to be supplied predominantly from Dar es Salaam with mercury likely to enter the country through Dar es Salaam Port.</p> <p>One shop owner at Kariakoo Market in Dar es Salaam related how he has Mozambican businesspersons buying mer-</p>

Country	
	<p>cury to supply to ASGM areas in northern Mozambique.</p> <p>Another entry point of mercury appears to be the border points of Tunduma (Zambian border) and Kasumulu (Malawian border) in southwestern Tanzania. Informants in Chunya District told how mercury, among others, is brought in by business people from Zambia and Malawi who buy the mercury in South Africa and Zimbabwe. One informant told how the better-off small-scale miners travel to Zimbabwe for mining related issues (especially cyanidation plants) and bring back mercury from these visits.</p> <p>According to one informant, mercury sold in Dar es Salaam is imported from Nairobi. While ASGM is relatively limited in Kenya, Nairobi has become a pivotal mercury supply nexus in East Africa, probably because it is a key gold buying centre as well as deemed a conducive business center (by foreign suppliers) for the regional market.</p> <p>An informant based in Chunya District divulged that purveyors from Zambia and Malawi furnish mercury to local shops and other distribution points in the southern regions wherefrom the commodity is covertly sold to ASGM operators.</p>
Uganda	<p>Most mercury appears to enter the country through the Kenya-Uganda border posts, especially those of Malaba and Busia, as well as from Tanzania, especially the border post of Mutukula. While the ports of Mombasa and Nairobi are closer to Uganda than Dar es Salaam, the main gold fields of Tanzania are located around Lake Victoria, prompting Tanzanian traders to bring some of their mercury on to Uganda.</p> <p>One license owner related that some Chinese companies smuggle in the mercury together with their mining equipment, concealing the mercury in cavities in the equipment. Some of the mercury smuggled into Uganda simply passes through the country on its way to DR Congo.</p>
Zimbabwe	<p>According to all informants, mercury comes from South Africa (one informant also mentioned Zambia), where it is imported by ship (ports of Durban and Cape Town) from a number of countries; China, India, Switzerland, and Russia were mentioned by informants. In South Africa the substance is legal to import and trade; therefore, it is traded by both small and large companies; companies such as Protea and Marilyn were mentioned as large trading companies.</p> <p>The most normal trade route is through the Beitbridge border post, where the substance is smuggled in various ways, through public transport, in private vehicles, and by using transporters specializing in smuggling. The mercury is smuggled into the country both in 34.5 kg flasks (two interviewees mentioned 47 kg flasks) and in smaller one-kg flasks, and often in used chest syrup flasks.</p> <p>One informant stated that suppliers get the mercury into the country through Beitbridge paying off drivers of long distance buses to ensure their parcels get safe across the border - the drivers conceal the mercury or pay-off customs officials. Bribery of customs officials has been mentioned by several informants.</p> <p>Mercury is banned in Mozambique and one informant stated that mercury enters Mozambique from Zimbabwe's eastern borders.</p>

## Trade routes in Eastern Africa

The field data from Tanzania, Kenya, Uganda and the Eastern Provinces of DR Congo indicates that the mercury is traded by various routes as indicated on the map below. The map has been generated combining information on trade routes collected in the different

mining areas of Tanzania. Besides the data collection from the field investigations as part of this project, staff from COWI Tanzania have collected information from mercury suppliers and users when travelling in the areas as part of other activities.



**Figure 2.13**  
Identified mercury trade routes in Tanzania, Kenya, Uganda and the Eastern Provinces of DR Congo

### Trade routes in Western Africa

From field visits in Senegal and Côte d'Ivoire it was noted that apparently the main entry points for mercury to the countries was not via the local ports, but mercury was reported to come from neighboring countries such as Mali, Guinea and Burkina Faso. From this it was suggested that Burkina Faso could be a major entry point for illegal mercury to the region and the mercury flows in Northern Côte d'Ivoire and Burkina Faso was further investigated. All information obtained from miners' organizations, miners and traders indicated that the mercury entered Burkina Faso from Ghana and Togo, both known to be major entry points for mercury. It has not been informed by any organizations that mercury could enter Burkina Faso from the North e.g. through the Sahara from Algeria or other countries in North Africa.

According to one miners' organization mercury flows in Burkina Faso are the result of an illegal traffic organized with some Burkina Faso citizens which emigrated to Ghana many decades ago. These people learnt from Ghanaian miners how to process gold. Many years later, they decided to share their technology with their relatives and friends who became artisanal miners too. In this technology transfer, they introduced mercury in the gold mining practice. Thus, these migrants in Gha-

na today supply artisanal miners in Burkina Faso, and even in many countries in West Africa. At the end of the chain, these same mercury suppliers are the one who buy the large amount of gold produced in ASGM. According to the organization, the gold bought by these dealers is sold in some parallel routes not under the control of mines administration.

According to another organization in Burkina Faso mercury used in ASGM managed by this organization comes generally from Ghana and Togo. It arrived in the ports of Lomé (Togo) or Tema or Takoradi (Ghana). The contact persons the organization have in these ports collect the mercury and pack it in different types of containers (5 kg, 25 kg or 50 kg). These mercury containers are transported by trucks, pick up vehicles, private cars or even motorbikes. To achieve their destination in Burkina Faso, they used unpaved roads in the bush, or all roads where there are not enough police controls. For that, the transport can take three days to two weeks before arriving in Burkina where the mercury is stored in villages far from main town or cities. It is just when mercury is needed for use in one ASGM site that a container is sent to that site.

All this activities are performed under an organized traffic with several people involved.

A part of the mercury entering Burkina Faso is further transported to Northern Côte d'Ivoire and Mali and from Mali further to Senegal.

According to a ASGM site owner in Northern Côte d'Ivoire, mercury used to extract gold comes from Burkina Faso where it is imported from Ghana. In Ghana, mercury is removed from ships during their cleaning and packed in bottles or containers of 5 liters. This mercury is mixed with wastes and once wastes are evacuated from the harbor to dumping sites, mercury containers are removed from the wastes and sent to some wholesalers. Then, the mercury is sent to Burkina Faso using unpaved roads where there is not or less control by police or customs. According to the informant, suppliers from Burkina Faso have the control of mercury import in this part of West Africa.

The example above, even the extrapolation of this anecdotal information should be done with care, illustrates what is probably one of more ways the mercury may illegally enter the region. If the information is correct, it illustrates that illegal mercury import is linked to illegal activities in the exporting countries where the mercury is hidden in the ships.

Trade flows for mercury used for ASGM in Mali, Guinea and Sierra Leone has not been studied within this project. The official import to the countries is very small, but it is not known if the mercury to these countries is imported via the well-established routes from Ghana and Togo, or the mercury is illegally imported directly from countries outside the region.

## 2.5 Mercury sources in Sub-Saharan Africa

### Primary mercury mining

According to available information, primary mercury mining does not take place in Sub-Saharan Africa.

The Global Mercury Assessment 2013 identifies one site contaminated with mercury resulting from primary mercury mining in South Africa, indicating that mercury has been mined in the past. According to the mercury inventory for the Republic of South Africa, however, primary extraction and processing of mercury, i.e. dedicated primary mercury mining, never took place in South Africa. USGS Minerals Yearbooks indicate production ranging from 204 to 836 tonnes of mercury per year in the Union of South Africa during the period 1941-1946, but do not report on mercury production for

the subsequent years. The Union of South Africa consisted of today's South Africa and Namibia.

The USGS Mineral Yearbook, country report for DR Congo, states that "*primary mercury mining has not taken place in DR Congo in recent years*". This may indicate that, historically, mercury was mined and the mineral ores for production of mercury may be present, but the minerals yearbook dating back to the 1930s does not indicate any production in DR Congo.

Besides the primary mining in South Africa mentioned above, the Minerals Yearbook 1936-1940 (the first yearbook with a separate chapter on mercury) states that a few flasks were produced in Southern Rhodesia (now Zimbabwe) in 1939 while for the following year, "Data not yet available" is indicated.

Mercury was mined in Algeria in significant quantities until 2004, and according to USGS this accounted for all of Africa's production since 1946.

### Import of mercury

As described in previous sections mercury is imported to Sub-Saharan Africa from other parts of the world. Historically, a major part of the import was from Europe but due to the EU export ban, mercury from East Asia and Mexico appears to be the major source entering the region at present (see Table 2.4).

### Chlor-alkali plants and other industrial uses of mercury

As described in section 2.2, only one chlor-alkali plant with mercury cell technology is in operation in the region (in Angola). The total amount of mercury accumulated in the cells at this plant would be approximately 21 tonnes and, in addition, some mercury may be stored on-site for replacement of mercury lost from the cells. Mercury in wastes, which potentially may be recycled, is estimated at approximately 1 t/year. The available information indicates that mercury from the plant, when decommissioned, would only account for a small portion of the total supply for one year in Sub-Saharan Africa. At a more local level, it is a possibility that mercury legally imported for the chlor-alkali plant is in fact sold for use in ASGM, but no evidence to confirm this possibility has been obtained.

As mentioned in section 2.2.1, it has been reported from a major importer of mercury in South Africa that some imported mercury from Algeria originates from a chlor-alkali plant. In this context, this source would be

included in the import of mercury from countries outside the region.

### By-product mercury

Globally, mercury extracted as by-product in non-ferrous metals and natural gas production, accounts for a significant portion of the total mercury supply. At the global scale in 2005, total mercury by-product production was 531 t/year; of this, gold refining represented approximately 50% (Maxson, 2006). For instance, mercury is extracted as by-product from gold production in the USA, Chile and Peru and from zinc in Finland and Japan.

A trading company in South Africa has for this study informed that they can provide approximately 21 t/year of mercury from South African sources. The information on recovery of mercury in South Africa has not been confirmed from other sources and the company has not provided more detailed information on the origin of the mercury. The Chamber of Mines in South Africa has been requested information on the quantity of by-product mercury recovered from the smelting of gold, but no data on mercury recovery or mercury in gold ore mined in South Africa have so far been obtained.

No information on production of by-product mercury from processing of other metals is available. By-product mercury from the production of non-ferrous metals may be a supply of mercury for ASGM in Africa in the future. A study performed by COWI for the European Commission (Maag et al., 2012) provided estimates on the remaining global potential for mercury removal in the non-ferrous metal sector with main technologies provided by a global supplier of dedicated mercury removal systems. The study provided data for the two large mining countries of South Africa and Zambia. According to the study, dedicated mercury removal systems are not applied in South Africa and Zambia to the knowledge of the technology provider, and it is likely that such systems are not applied in any of the countries in Sub-Saharan Africa. According to the study, the remaining potential for mercury removal in the non-ferrous metal sector with main technologies is 0-5 t/year in South Africa and 0-5 t/year in Zambia. No data are available from other countries in the region. The total would therefore be 0-10 t/year.

Another indication of the potential for by-product mercury production is the estimated air emissions from the

processes as reported in national mercury inventories, which have used the UNEP Mercury Toolkit. The mercury inventory for South Africa indicates that in total 87 t/year of mercury is released to air from industrial gold production while another 14 t/year is estimated to be released from other non-ferrous metal production. The mercury inventory for Tanzania estimates an air emission of 40 t/year from industrial production of gold. In Zambia, the total emission from copper and gold production is estimated at 2.9 t/year. The latter is well in accordance with the data from the European study. The air emission from industrial gold production in South Africa and Tanzania are estimated on the basis of intermediate default emission factors from the UNEP Mercury Toolkit, which are based on data from industrial gold production in North American conditions; these may overestimate the releases. In consequence, the actual releases may be lower.

An alternative approach to estimating mercury from industrial gold could be based on the total industrial gold production in the region and use of the full range of default factors from the UNEP Mercury Toolkit:

- > Total industrial gold mine production in the region: 500 t/y
- > 250,000 tonnes gold ore used per tonne gold produced
- > Mercury content of ore: 1-30 g/t (the toolkit suggests an intermediate value of 15 g/t as default if nothing else is known)
- > Part of mercury input released to air: 4%

On this basis, total mercury releases to air by industrial gold can be estimated at 5-150 t/year, which potentially could be recycled using dedicated mercury removal systems. The (industrial scale) gold industry has stated that the actual mercury content for gold ores in South Africa and other countries in the region would likely be in the lower end of the range, but actual data demonstrating mercury content of gold ores from the region have not been made available.

### Summary of potential mercury sources for ASGM in Sub-Saharan Africa

An estimate of the current mercury supply sources in Sub-Saharan Africa is presented in Table 2.15. Based on the available information, it is assessed that import represents close to 100% of the supply of liquid mercury used for ASGM in the region.

**Table 2.15***Best estimates of mercury supply sources in Sub-Saharan Africa*

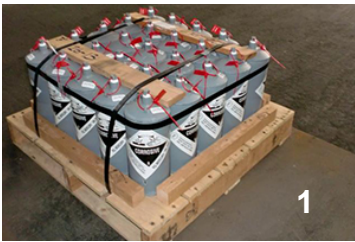


Source	Estimated supply in 2014 t/year	Remark
Primary mining	~0	Mercury was mined in South Africa during 1941-1946 (probably because of the limited access to mercury from continental Europe) but since then no primary mercury production in Sub-Saharan Africa has been reported.
Import from countries outside the region	200-375	Estimated on the basis of the expected consumption of mercury for ASGM (205-492 t/year), the average reported import of liquid mercury in 2012-2015 of approximately 200 tonnes and possible informal import and import of mercury under other commodity codes.
Mercury from decommissioned chlor-alkali plants and other chemical plant	~0	The total mercury accumulated in the cells of the only chlor-alkali plant in the region is estimated at approximately 21 tonnes. Mercury in wastes which potentially may be recycled is estimated at approximately 1 t/year.
Recycling of mercury from mercury added products	1-3	Assumed to be 3-15% of mercury in products placed on the market. The amount may increase with incentives due to mercury supply shortages. If 50% of all mercury in mercury-added products was recycled, the quantity could increase to 14-19 t/year.
By-product mercury from processing of other metals	0-25	A trading company in South Africa has for this study informed that the company can provide approximately 21 t/year of mercury recovered from South African gold mines. The information on recovery of mercury in South Africa has not been confirmed from other sources. Furthermore, it has not been possible to get a reconfirmation of the information from the company. See description in main text.
By-product mercury from gas processing	0	UNEP (2006) suggests, based on data on mercury impurity of natural gas in South Africa, that the concentrations in wellhead gas are at levels where likely the gas should be cleaned (whereby by-product mercury potentially may be produced). No information on production of by-product mercury from processing of other metals is available, but by-product mercury is likely not produced from natural gas in the region in any significant quantity.
Total (rounded)	200-400	

## 2.6 Overall mercury value chain

Information on the overall mercury value chain is summarized in Figure 2.14. In fact, many different value chains exist in parallel. In order to provide an overview only the most typical steps and actors are included; reference is made to the previous sections for more details.

The overall trade flow model with major is shown in Figure 2.14. Volumes of mercury imported from countries outside the region are indicated for the import countries as an average of 2010-2015 numbers with 2015 in brackets. The official import data are consid-

ered to indicate which countries are the main importers, but for some of the countries the quantities are probably reported as too low. It is estimated that the quantities for some of the import countries could likely be up to twice the indicated quantity. The yellow circles indicate the consumption for ASGM in the countries. Major areas for ASGM in Sub-Saharan Africa are Ghana (whole country), Sudan (whole country), the area around Lake Victoria (part of Tanzania, Uganda, Kenya and DR Congo), and Zimbabwe (whole country). Besides direct import to the countries (in particular Sudan), three countries serves as hubs for mercury trade to the three of the areas: Togo, Kenya and South Africa.

Step in value chain	Identified actors	Purchased quantities	Price	Illustration
Import of mercury from countries outside Sub-Saharan Africa	A: Trading companies specialized in mercury and other metals B: Trading companies with wide portfolios; e.g. in agricultural products	Typically 50-500 flasks (2-17) tonnes)	2015: Average value of imported mercury in the USD 40-59/kg range 2016: Average value probably in the USD 29-43/kg range	
Official trade of mercury within the region and other trade in larger quantities	A: Trading companies specialized in mercury and other metals. B: Gold merchants	Typically 5-50 flasks (0.2-2 tonnes)	Prices in South Africa reported to be in the USD 13-101/kg range	
Transport of mercury from urban centers to the ASGM sites Informal import	A: Individuals or small companies specialized in mercury trade B: Gold merchants C: ASGM miners and financiers (e.g. claim owners)	Typically 1-6 flasks (35- 207 kg)	USD 78-92/kg (Tanzania and Zimbabwe) USD 34/kg (Kenya)	
Users of the mercury (small scale)	Larger custom millers or amalgamation centers (see above for users buying larger quantities)	Typically 0.75- 1 kg containers	USD 75 -160/kg (Zimbabwe and Tanzania); USD; 150- 200/kg (Uganda).	
Users of the mercury (artisanal scale)	Artisanal miners	Typically 30-50 g containers  or 10 g plastic bags	Ranging from: USD 75-95/kg (Ghana and Côte d'Ivoire); USD 120-330/kg (other countries).  USD 330 (Zimbabwe)	

**Figure 2.14**

Overall value chain of mercury used in ASGM. Photos: 1) Belray Metal Trading, South Africa; 2) 34.5 kg Mercury flask bought in Accra and brought to the mining site in Ghana by the license owner; 3) One kg mercury bottle at ASGM site in Zimbabwe. Photo: R. Kitungano; 4) Mercury (30-50 g) in eye-drop container at ASGM site in Ghana. 5) Plastic bag with approximately 10 g sold at a mining site in Zimbabwe.



### 3 Consumption of mercury in Sub-Saharan Africa

This section addresses intentional consumption of mercury in Sub-Saharan Africa. The majority of the intentional use of mercury is for ASGM which is described below in a separate section.

#### 3.1 Mercury use in ASGM and gold production

##### **Trend in mercury use for ASGM in the region**

Gold bearing ores are widespread throughout Sub-Saharan Africa. As discussed in section 1.1.1, gold production data are available from about 32 countries in the region, and for other 6 countries it is indicated that gold is produced, but data not available.

ASGM with mercury amalgamation is widely applied in the region, and the mercury use for ASGM has been estimated for 38 countries in the region in the most recent Global Mercury Assessment.

Available estimates of the total use of mercury for ASGM in Sub-Saharan Africa are shown in Figure 3.1. For 2010 and 2015, the data are based on mean figures for each country in the region (data presented in Table 3.1).

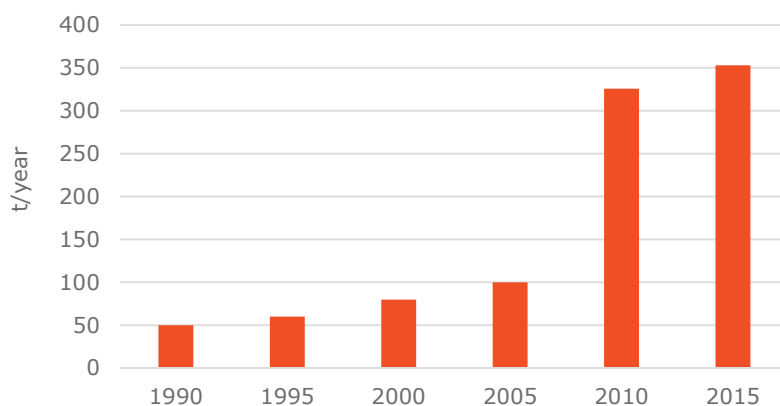
In the Global Mercury Assessment, the total estimated consumption of mercury for ASGM in Sub-Saharan Africa in 2010 is estimated at a total of 327 t/year (range 187-467 t/year, if min and max figures are simply

added). The updated mean estimate including data from this study is 349 t/year (range 205-492 t/year if min. and max. figures are simply added).

The steep increase from 2005 to 2010 may be due in part to an actual increase in consumption, likely to be a direct result of increase in gold mining due to a significant rise in gold prices and more people being attracted to the ASGM sector, and in part to changes in the methodology used for the estimates. According to the Global Mercury Assessment 2013 (AMAP/UNEP, 2013), the increase in global ASGM mercury emissions (and the consumption resulting in the emissions) is mainly due to more and better data for countries for which the emissions were previously poorly estimated, such as the West African countries. The countries were formerly only reported as having a presence of ASGM and therefore assigned a minimal value of 0.3 t/year. The largest change reported in the Global Mercury Assessment 2013 for any region is for Sub-Saharan Africa.

Increased use of mercury from 2010 to 2015 is specifically reported for Sudan and Uganda. With the increased production, Sudan has become the major consumer of mercury for ASGM. For some countries, the estimates are either higher or lower in this study as compared to the Global Mercury Assessment, but these findings are mainly due to differences in the data available and the assessment of these data.





**Figure 3.1**  
Time trend in estimated total mercury consumption for ASGM in Sub-Saharan Africa (mean estimates). Sources: 1990-2005: AMAP/Wilson et al. 2010.; 2010: Summary of data from Global Mercury Assessment shown in Table 3.1. 2015: estimates from this study shown in Table 3.1.

### Consumption of mercury for ASGM by country

The Global Mercury Assessment 2013 (AMAP/UNEP, 2013) estimated a total of 327 t/year (range 187 - 467 t/year) as mentioned previously. The total mean estimate for the eight countries selected for this study was 193 t/year corresponding to 58% of the total for the region. Among the top five countries, four are participating in this project: Ghana, Tanzania, Burkina Faso and Zimbabwe. The other major country is Sudan.

The estimates in the Global Mercury Assessment has been re-evaluated for:

- > The 8 participating countries;
- > The following countries providing data for the study by answering a questionnaire: Botswana, Central African Republic, Chad, The Gambia, Gabon, Lesotho, Kenya, Malawi, Mali, Mauritius, Sao Tome and Principe, Sierra Leone and Swaziland;
- > Sudan, for which a detailed survey has recently been published.

The participating countries and the countries for which the data have been reevaluated collectively represent about 87% of the total consumption.

It should be noted that detailed estimates are expected to be available from all countries in the region during the next two years as part of the development of the countries' National Action Plans (NAPs) for ASGM. The development of the NAPs is a part of the enabling activities of the countries' accession to the Minamata Convention. The re-evaluation undertaken here has been done on the basis of a limited dataset and the aim has primarily been to assess the total estimated consumption

in view of understanding the trade flows. More exact estimates are expected to be undertaken as part of the development of the NAPs in each country.

A short description of the current situation with regard to the knowledge level, number of ASGM miners, trends, and estimated mercury use in the participating countries, Sudan and a few other countries are provided below. A more detailed description for each of the participating countries is provided in the country sections of a separate report. The description has been organized with the major ASGM countries first.

The participating countries in addition to countries for which the data have been re-evaluated in total represent about 87% of the total consumption.

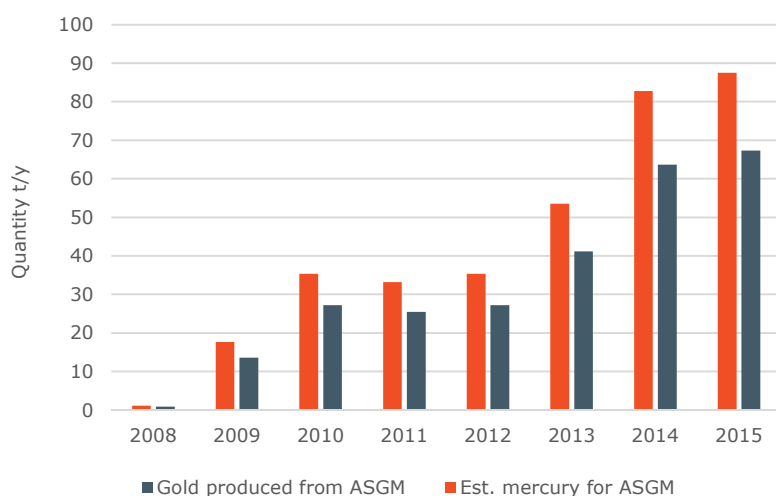
**Sudan and South Sudan** - An inventory of ASGM sites in Sudan and the gold production in the country have recently been published (Ibrahim, 2015). The study covers 221 sites in the country. More than one million miners are involved in ASGM in the country; ASGM activities cover 14 of the 18 Sudanese states. In the report it is indicated that the gold produced by ASGM is extracted by amalgamation and that the 221 sites included 822 amalgamation centers. According to the study, total gold production has been steadily increasing from a level of around 10 tonnes in 2008, to over 32 tonnes in 2010 to 73 tonnes in 2014 (and 62 tonnes for first 3 quarters of 2015). About 85% of the gold was produced by ASGM. If a mercury to gold ratio of 1.3:1 is applied (amalgamation from concentrate), the 64 tonnes gold produced by ASGM in 2014 corresponds to 83 tonnes mercury. For gold production from concentrate, a ratio of 1.3 g mercury for g of gold (i.e. weight ratio 1.3:1) in commonly applied, but the ratio may range from 1 to 3 g mercury for each g gold (Persaud

and Telmer, 2015). The estimated mercury consumption is shown in the figure below along with the data on gold production (Figure 2.3). Considering the uncertainties related to the mercury to gold ratio, the total mercury consumption in Sudan in 2015 is estimated in this study at 63-103 t/year (median 83 t/year).

The total mercury consumption in former Sudan (now Sudan and South Sudan) in 2011 was estimated at 60 t/year (range: 30-90 t/year) in the Global Mercury Assessment (AMAP/UNEP, 2013). It was assumed that all gold was produced by amalgamation from concentrate

i.e. a mercury to gold ratio of 1.3:1 was applied. Considering the data presented in Figure 2.3, the consumption in 2011 was likely in the lower end of the range, but consumption in 2015 was more than twice the consumption in 2011.

The estimate of the Global Mercury Assessment also covers the area which today is South Sudan. According to a report on mining in South Sudan from Cordaid (2016), mercury is not used for artisanal gold mining in South Sudan as the gold is extracted from alluvial deposits without use of mercury.



**Figure 3.2**

*Estimated mercury consumption for ASGM in Sudan. Gold production from ASGM in 2013-2015 is specifically indicated by the source. Total mercury consumption in 2015 has been extrapolated from data for the first three quarters of 2015. For the period 2008-2012 gold from ASGM was calculated from total reported gold production assuming that ASGM represents 85% of the total production (i.e. same percentage as in 2013-2015). Mercury consumption has been estimated from reported gold production assuming that 1.3 g mercury is used to produce 1 g of gold.*

**Ghana** - Ghana's ASGM sector is significant. There are currently 1,355 small-scale mining claims and an estimated number of artisanal and small-scale miners of close to a million. Mercury is widely used and available in and around mining sites. The ASGM sector in Ghana has been described in many academic papers focusing on different aspects but with limited information on the mercury trade.

According to Wilson et al. (2015), while ASGM represents a relatively small proportion (~10%) of Ghana's annual gold mining production, it is a growing sector that affects the livelihood of increasing numbers of people each year. In 2011, approximately 6.9 tonnes of gold extracted by ASGM activities were purchased by two Ghana-based mining companies (Precious Minerals Marketing Corporation and Asap Vasa). This does not include an unknown - but estimated to be substantial - revenue from sales through informal markets and non-traditional means. The following year, ASGM production rose by 43% to 10 tonnes. The actual produc-

tions of gold by ASGM is considered to be substantially higher than these official data. The US Geological Survey Minerals Yearbook for Ghana estimates the gold production from ASGM in 2010 at >25 tonnes and in 2011 at >30 tonnes. Assuming a mercury to gold ratio of 1.3:1, this estimate would correspond to more than 39 tonnes of mercury; the quantities could be considerably higher.

The Global Mercury Assessment (AMAP/UNEP, 2013) estimated the consumption of mercury for ASGM in Ghana in 2010 at 49-91 t/year (mean: 70 t/year), the highest consumption in any country in Sub-Saharan Africa at that time. Considering the size of the population of miners and the estimated gold production, this estimate is maintained as the best estimate for 2015 even though the actual consumption is possibly in the low end of the range.

**Tanzania** - A draft baseline survey of ASM activities in Tanzania estimates a total of 680,000 ASM miners in

the country; of these, 391,000 are involved in ASGM (MTL, unpublished draft). According to the survey, the number of ASGM miners in the country has increased from 223,000 in 1996 to 392,000 in 2015.

Gold mining activities in Tanzania are concentrated around the Lake Victoria gold fields (in the regions of Mara, Simiyu, Mwanza, Geita, Kagera, Shinyanga, Tabora and Singida) and southwards to the Katavi and Mbeya regions. However, there are smaller operations taking place in most of the country's regions including Arusha, Tanga, Morogoro, Njombe, and Ruvuma. Although there have been initiatives to reduce the usage of mercury in ASGM, especially the Global Mercury Project around 2006-2008, a highly limited number of people use retorts or other mercury-reducing methods and mercury is still widely used and available throughout Tanzania's ASGM sites. The above-mentioned draft survey found that only 7.7% of the investigated sites visited showed good handling and amalgamation practices (not further defined). The dominant extraction method in Tanzania is through concentration, with whole ore amalgamation being either rare or non-existent. During the last ten years, between 100 and 200 cyanidation leaching plants have been established throughout Tanzania's ASGM sites. While these pose an environmental and health threat if not managed properly, they are likely to have reduced the usage of mercury in certain areas. The Global Mercury Assessment (AMAP/UNEP, 2013) estimates, on a limited data basis (indicated as educated guess at the MercuryWatch database), the total consumption in 2009 at 31.5 - 58.5 t/year (mean: 45 t/year). Using the average mercury consumption per miner of 130 g/year of sample sites investigated in this study (taking mercury recycling into account), the total mercury consumption can be estimated at 45-56 tonnes per year (mean 50 t/year). The actual uncertainty is, however higher, as the sample sites represent only 1% of the total miner population. Based on the available information, it is estimated that the total mercury consumption in Tanzania in 2015 was in the range of 30-55 t/year.

**Burkina Faso** - Burkina Faso is used as an example for calculation of the mercury use for ASGM in the Global Mercury Assessment 2013 (AMAP/UNEP, 2013). The estimate is based on data collected through a two year period (2011-2012) and is considered to represent the best assessment of the mercury use in the country.

According to Ministry of Mines, Geology, and Quarries (as cited by AMAP/UNEP, 2013) about 600,000 adults are living on 221 ASGM sites that are registered as having ASGM exploitation permits. At least the same number inhabits and operates on unregistered land. The results of meetings with various stakeholders were as follows (AMAP/UNEP, 2013):

- › "All ASGM activities use Hg. This began around year 2000.
- › Whole ore amalgamation is never done. Concentrate amalgamation is done.
- › Mercury activation is not practiced. Miners do not throw away dirty Hg. Miners never use retorts or recycle Hg in other ways – amalgam is burned using an open flame.
- › The amount of Hg used per unit gold produced is on average 1.3 parts mercury to 1 part gold (i.e., a mercury to gold ratio of 1.3:1). This accounts for the Hg that ends up in the amalgam (1 part) and the Hg that is lost during processing to the tailings (0.3 parts).
- › All Hg used is released to the environment, with 75% (that in the amalgam 1/1.33) directly emitted to the atmosphere during amalgam burning and the residual (0.3 parts) lost to the tailings.
- › In Burkina Faso, it is likely that the amount lost to the tailings is re-emitted to the atmosphere on a relatively short time scale of one to several years as the tailings are accumulated in above ground piles and later reprocessed.
- › 200 000 of the 600 000 official ASGM population (1 in 3) are estimated to be active miners.
- › They produce 20 to 30 tonnes of gold per year (~25 tonnes)."

This estimate was discussed with the gold buyers and site owners and the Ministry of Mines and was found to be reasonable by these groups.

No new data are available (contradicting the assumptions on which the mercury consumption was estimated), and the estimate for 2011-2012 is used here as a best estimate for 2015.

**Zimbabwe** - The ASGM sector in Zimbabwe is significant as well as advanced compared to many other

ASGM sectors in Sub-Saharan Africa. The sector covers a broad spectrum from informal artisanal miners, known as Makorokozas, to highly mechanized small-scale mining operations. The sector is organized around 450 privately owned so-called custom milling centers, which transport, crush, concentrate and amalgamate (with mercury) the ore for limited funds, after which they make their money from cyanidation. However, a great deal of gold is also extracted outside the milling centers, predominantly with mercury (only few mercury-free initiatives exist). The mercury to gold extraction ratio for coarse gold is higher than for fine gold; 2:1 for coarse gold and 1-1.5:1 for fine gold. The ASM population is estimated at 500,000; some estimates are higher than this, and most observers agree that the number is at least 500,000 miners. PACT (2015) uses an estimate of the ASM population of 500,000 for a socioeconomic baseline survey. It is not specifically indicated how many of these are involved in ASGM, but it is assumed to be the majority. The number of people who have been involved with ASM during the last decade is likely several million, as people move in and out of the sector and, in many cases, engage in ASM, as part of a diversified livelihood strategy that also includes agriculture and other activities. The number of Certificates of Registration (the term for ASM licenses) is approximately 40,000 and of these 8,000 have had an Environmental Impact Assessment (EIA) conducted.

One mercury trader informed the study that each milling center uses approximately 2 kg of mercury per week. With 450 centers across the country the total annual consumption would correspond to 47 tonnes mercury if the centers work throughout the year. In addition to this mercury, the mercury used outside these centers must also be taken into account, an amount likely to constitute a significant tonnage.

The Global Mercury Assessment estimated the consumption of mercury for ASGM in 2009 at 12.5 - 37.5 t/year (mean: 25 t/year). Different from other countries in the region, it was assumed that 80% of gold was produced by whole ore amalgamation, which results in significantly higher mercury to gold ratios than amalgamation from concentrate. At all five sites visited during the field training as part of this project gold was produced by amalgamation from concentrates. This could indicate that amalgamation from concentrates is more common in Zimbabwe today, but more site investigations as part of the development of the national action plan is required. The estimates used in the Global

Mercury Assessment originates from the Global Mercury Project (GMP) report for Zimbabwe (GMP, 2007). The report notes that the estimated numbers of people mining in Zimbabwe has varied considerably. In early 2006, estimates suggested there could be as many as 500,000 miners in the whole of the country, while only 100,000 were active in 2007. In a study completed in 2006, the GMP surveyed mercury imports into Zimbabwe and concluded that official imports had totaled between 20 and 25 tonnes per year for the period 2001-2005. The estimates of mercury consumption were based on these data. As most mercury is today imported illegally, it is not possible to update the estimate on basis of import data. In the absence of newer data, the estimate from the Global Mercury Assessment is used as best estimate.

**DR Congo** - Gold is predominantly extracted in the Eastern part of the country in the provinces of South and North Kivu, Haut-Uele and Ituri, though ASGM is also found in the far west of the country, in the Province of Bas Congo, close to the border with Angola. Estimates of the ASGM population varies significantly, however, it is likely to directly involve somewhere between 500,000 and a million people.

According to the US Geological Survey Minerals Yearbook for DR Congo, between 1.8 and 2 million artisanal miners were estimated to be employed in DR Congo in 2012, including between 100,000 and 130,000 miners in gold mining in the Ituri Interim Administration of Orientale Province (now Ituri province). The estimated gold production by ASGM in this province was estimated at 6 t/year.

Available estimates for the number of artisanal miners in the Kivu provinces, for example, taken from 2007 and 2010 respectively, put the figure between 200,000 and 350,000 (D'Souza, 2007; PACT, 2010).

According to OECD (2015) the number of ASGM miners in 860 surveyed gold mining site in 2013 was 176,000. Based on production data from visited sites the gold production by artisanal miners in Eastern DR Congo in 2013/14 is estimated at 8-10 tons of gold. It is not reported to what extent mercury is used for the extraction.

Estimates of the ASGM population varies significantly, however, it is likely to directly involve somewhere between 500,000 and a million people.

The total mercury consumption in DR Congo is in the Global Mercury Assessment estimated at 3.8-26.3 t/year. Considering the estimated number of miners and the information of old production in Ituru province the actual consumption is likely well above the minimum of this estimate. However, in absence of detailed surveys the range from the Global Mercury Assessment is used as best estimate.

**Senegal** - According to Persaud (2015), in April 2014, a mixed-methods rapid appraisal study was carried out over a three week period in the gold mining region of Kedougou, Senegal. The study involved data on number of miners and shafts, gold production per miner and shaft, and revenues per miner at eight sample sites.

In order to estimate the total national mercury use for ASGM in Senegal in 2014, the following parameters and observations were used:

- › Total number of miners in Senegal of 67,000 (34,000-99,000). The number was derived from a previous inventory. According to a 2008 study, ASGM in Senegal was estimated to employ between 30,000-50,000 people directly on 55 sites. The number was verified for the 2014 study with local experts and key informants that included local customs authority representatives and government sources. In the absence of any data on some small and medium sized mines, population factors were applied, where small mines were given a 225 person mean population factor and medium-sized mines a 675 mean population factor.
- › Estimated average annual gold production per miner of 67 g/miner. This figure is based on observation on 8 sites with an estimated miner population of approximately 33,000 miners. The annual gold production per miner varied among the sites from 19 to 148 g/miner. The 90% confidence level based on the dataset can be estimated at 25-110 g/miner.
- › The observation that in general amalgamation from concentrate was applied in the country.
- › A mercury to gold ratio of 1.3:1 is used for mining operations where mercury was applied. The observed ratios ranged from 1.1:1 to 1.6:1. The ratio 1.3:1 corresponds to the average observed for West Africa. With an observed gold production per miner of 67 (25-110) g/miner the mercury use per

miner (where mercury is used) would be estimated at 87 (33-143) g/miner.

- › An estimated percentage of total gold production produced by mercury-free processing. For all colluvial<sup>5</sup> sites a 50% reduction on mercury use was applied to reflect the cases of mercury-free processing at these sites.

The results of this study portray an ASGM sector composed of approximately 67,000 (34,000-99,000) miners, producing an estimated 4.5 (2.3 - 6.7) tonnes of gold per year and using approximately 5.2 (2.6-7.7) tonnes of mercury per year. Note that reported uncertainties on gold production and mercury use numbers only take into account the uncertainties on number of miners and may underestimate the actual uncertainty. Other uncertainties, as e.g. the uncertainty regarding the average gold production per miner, are not included in the assessment of the uncertainty.

Data collected as part of a more recent socioeconomic study indicate that around 2/3 of the sites investigated were using mercury. In the sites using mercury, only a few miners used mercury in 1/3 of the sites, whereas most of the miners use mercury in 2/3 of the sites. Retorts or other mercury recovering system were not applied on any of the sites (Baptiste, personal communication). This more recent study found that the annual amount of gold extracted per miner ranged from 36 to 533 g/miner between sites. This illustrates that the estimates are quite sensitive to the assumptions regarding the average annual production per miner.

So far, the estimates by Persaud (2015) are considered the best available until a more detailed inventory is undertaken as part of the development of the NAP, and the estimate used as best estimate in this survey.

**Uganda** - The Ugandan ASM sector may be as big in population as 200,000 including mining of aggregates, lime, salt, sand, etc. However, the ASGM population is estimated to be around 40,000, a number that has increased significantly since a number of new gold discoveries and subsequent rushes took place in 2013-2015. The use of mercury was not widespread around the millennium, and was probably only used regularly in Busia. Mercury use has grown in recent years and

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<sup>5</sup> Colluvium is a general name for loose, unconsolidated sediments that have been deposited at the base of hillslopes.

mercury is now used in most hard rock operations in the country. It is predominantly applied to concentrate, with an estimated mercury-gold ratio of 1:1 to 2:1. At least one site, whole ore amalgamation is used with an expected higher mercury to gold ratio. No recent estimates on the use of mercury for ASGM in Uganda exist. Considering the number of miners, and comparing to the situation in Tanzania with operations quite similar to those in Uganda, it is estimated that the total mercury consumption for ASGM in Uganda in 2015 could likely be one tenth of the consumption in Tanzania. It is consequently estimated at 2 - 6 t/year (mean 4 t/year).

**Côte d'Ivoire** - Until 2002 little to no mercury was used by small scale gold miners in Côte d'Ivoire. However, when the country was split up during the rebellion in 2002, a massive influx of small-scale gold miners from neighboring countries, first of all Burkina Faso, was observed in the northern part of the country; those miners introduced amalgamation in gold extraction. According to the Artisanal Miners Association, about 95% of workers in the sector come from foreign countries (Mali, Burkina Faso, Guinea, Ghana, etc. and even China). It was reported that large amounts of mercury are used in ASGM, but no dependable figures for these quantities exist, since there is no control of all artisanal miners. The majority of the gold is mined from alluvial deposits; the mercury to gold ratio is typically 2:1. The Global Mercury Assessment estimated the consumption in 2010 at 0.1 - 0.5 t/year, the default range applied in the assessment for countries with no information, but known ASGM. The artisanal Miners Association have been requested information on number of ASGM miners in the country. The association does not hold information on number of miners as the sector is still not well organized. but inform that in just one cooperative the number of workers is about 10,000. The Ministry of Mines neither have any information on number of miners. According to answers from NGOs in Côte d'Ivoire to a survey undertaken for UNEP Chemicals by Fritz (2014a), the number of miners in 2014 was 30,000-50,000. If this is correct, the consumption could probably be significantly higher than the estimated 0.1 - 0.5 t/year. The actual consumption is on this background estimated at some 0.5-5.0 t/year.

**Central African Republic** - According to a questionnaire response from the Ministry of Environment in the Central African Republic, no data are available on the use of mercury for ASGM in the country. According to the response, the number of miners involved in mercur-

ry-based ASGM in the country is estimated at approximately 400,000, possibly indicating mercury consumption significantly higher than the 0.1-0.5 t/year applied in the Global Mercury Assessment as default for countries with no information, but known ASGM. The USGS Mineral Yearbook reports gold production from ASGM in the country at about 50 kg/year for the period 2009-2013, but has no data from recent years. It is further indicated that diamonds and gold are the only minerals for which data have been reported from the country. Matthyssen and Clarkson (2013), in a report on gold and diamond mining in the Central African Republic, mention that illegal exports may represent more than 95% of the country's actual gold exports. Gold production estimates including illegal exports exceed 2 t/year. The authors estimate the ASM sector to employ 80,000-100,000 miners for diamonds and gold extraction while 600,000 people depend at least partly on the sector for their income. The report indicates that mercury is used for ASGM and that it is feared that the influx of migrant miners might introduce the use of mercury more widely. On this basis, it is roughly estimated that the mercury consumption in the Central African Republic is likely in the range of 3-12 t/year. No data on the origin of mercury in the Central African Republic is available, but it may be smuggled in from neighboring Sudan which is the largest mercury import country in the region.

**Sierra Leone** - According to the questionnaire response from the Environment Protection Agency, approximately 50% of the gold from ASGM in Sierra Leone is produced with the use of mercury. The total population of ASGM miners possibly using mercury is reported to be 100,000-200,000 of a total ASGM population of 200,000-400,000. This could indicate mercury consumption significantly higher than the 0.1-0.5 t/year applied in the Global Mercury Assessment as default for countries with no information, but known ASGM. Considering the number of ASGM miners using mercury and the experience from other countries, mercury consumption is roughly estimated at 2-20 t/year.

**Mali** - According to the questionnaire response from the Environment Protection Agency, approximately 200,000 miners are involved in ASGM in the country; of these, approximately half uses mercury, i.e. some 100,000. The quantities of gold produced by ASGM is reported to be 4 t/year. The same data was presented by the SAICM focal point for Mali for an ASGM meeting in Nigeria 2011 (UNEP, 2011).

The US Geological Survey Minerals Yearbook for Mali estimates the gold production from ASGM in 2013 at more than 6 tonnes.

These data could indicate that the 14-26 t/year estimated in the Global Mercury Assessment overestimates the actual consumption (the Global Mercury Assessment provides no reference for the estimate). The data reported in the MercuryWatch database (MercuryWatch 2016) is 1-2 tonnes with reference to a document from 2008. According to the available information, the gold from ASGM is mainly produced by amalgamation from concentrate. For this method, a default mercury to gold ratio of 1.3:1 may be applied, even though the ratio may be higher. On this basis, the mercury consumption in Mali is estimated rather to be in the range of 5-20 t/year.

**Kenya** - According to the questionnaire response from the Ministry of Environment and Natural Resources, the total production of gold from ASGM is estimated at 0.6 t/year. According to the response, the total numbers of ASGM miners using mercury is reported to be approximately 20,000. The mercury use for ASGM in Kenya is estimated at 1.9 - 13.1 t/year in the Global Mercury Assessment based on data from 2002. Based on the available data it is estimated that the actual mercury consumption in Kenya is more likely in the range of 1-6 t/year (mean value 3.5 t/year).

**Republic of South Africa** - No newer data on the use of mercury for ASGM in South Africa is available. The number of miners involved in ASM in South Africa is estimated to be anywhere from 8,000 to in excess of 30,000 (SAHRC, 2015). The main commodities mined by ASM in South Africa are diamonds and gold. According to a pamphlet from the Chamber of Mines of South Africa (COM, 2016), illegal artisanal mining is on the rise in South Africa and currently approximately

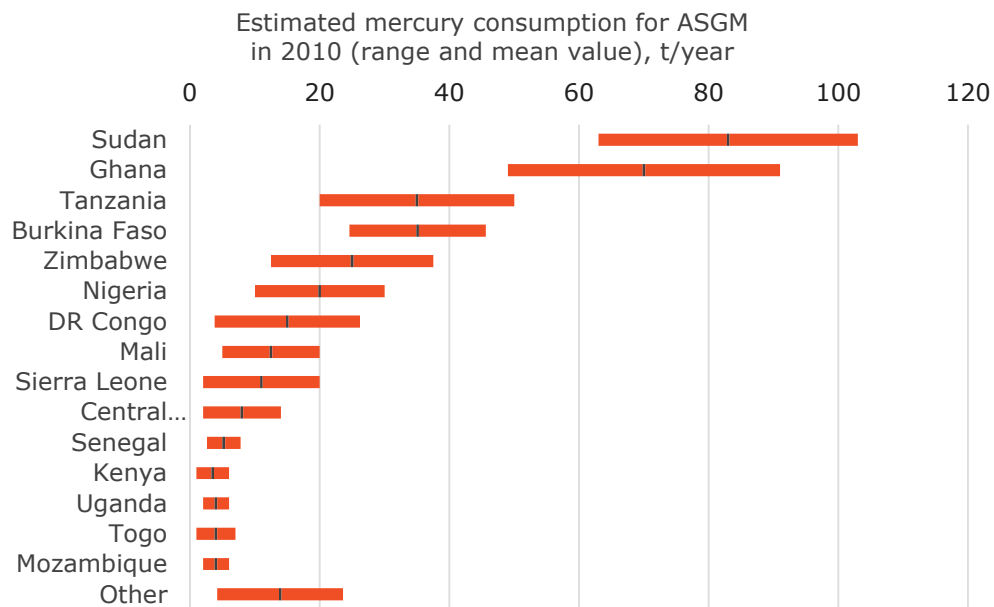
14,000 people are involved in illegal ASM. The total mercury use for ASGM in South Africa is estimated at 1.9 - 13.1 t/year (mean value 7.5 tonnes) for 2005 in the Global Mercury Assessment. Considering the relatively low number of miners involved, mercury consumption is more likely in the range of 1-6 t/year (mean value 3.5 t/year).

**The Gambia** - According to the questionnaire response, mercury is not used for ASGM in The Gambia although the country experiences "*a downstream effect due to the activity being conducted upstream in a neighbouring country*". During the ASGM workshop in Nigeria in 2011 (UNEP, 2011), it was reported by the representative from The Gambia that officially, mining was not taking place in the country but that inter-boundary ASGM activities were suspected to take place across the border between Eastern Senegal and the Alohungari and Sabi areas of The Gambia. It was emphasized that the mining taking place was mostly illegal and more as a result of trans-border activities from Senegal and Mali. For this reason, the estimate of 0.1-0.5 t/year from the Global Mercury Assessment is maintained.

**Countries with no reported use of mercury for ASGM** - According to the received response to the questionnaire sent to all countries in the region in this study, mercury-based ASGM does not take place in the following countries (the list cannot be considered exhaustive as not all countries answered): Mauritius, Malawi, Lesotho, Sao Tome and Principe and Lesotho.

### Summary by main ASGM countries

The estimated mercury consumption by the main countries in 2015 is shown in Figure 3.3.

**Figure 3.3**

*Estimated mercury consumption for ASGM in 2015, range and mean value.*

For four of the countries in Table 3.1, each indicated consumption of 0.1 - 0.5 t/year in 2010; the USGS Minerals Yearbooks for the countries do not indicate any production of gold for The Gambia, Guinea Bissau, Lesotho and Malawi (see Appendix 3). For this study, Malawi and Lesotho have stated that ASGM does not take place in the countries, whereas The Gambia has informed that ASGM may take place in some border re-

gions. For Malawi and Lesotho the re-evaluated estimate is consequently 0 t/year.

The data indicates that ASGM using mercury takes place to some extent in nearly all countries in the region with exploitable gold deposits. For only two countries with reported gold production (out of 38 countries), the Global Mercury Assessment does not estimate any use of gold by ASGM: Eritrea and Namibia.



**Table 3.1**  
*Mercury use for ASGM and calculation of associated emissions according to the Global Mercury Assessment (UNEP 2013a)*

Country	Data from Global Mercury Assessment 2013							Re-evaluated estimates from this study*		
	Quality of data <sup>a</sup>	Mercury consumption, t/year			Percentage of total Hg applied to concentrate amalgamation *	Percentage of total Hg applied to whole ore amalgamation	Year of most recent data	Mercury consumption, t/year		
		min	mean	max				min	mean	max
Angola	1	0.1	0.3	0.5	100	0	2009			
Benin	1	0.1	0.3	0.5	100	0	2010			
Botswana	2	0.2	0.8	1.4	50	50	2010		**	
Burkina Faso	4	24.6	35.1	45.6	100	0	2011	24.6	35.1	45.6
Burundi	1	0.1	0.3	0.5	100	0	2010			
Cameroon	2	0.4	1.5	2.6	100	0	2011			
Central African Republic	1	0.1	0.3	0.5	100	0	2010	2	8	12
Chad	1	0.1	0.3	0.5	100	0	2010		**	
Congo	2	0.4	1.5	2.6	100	0	2010			
Cote d'Ivoire	1	0.1	0.3	0.5	100	0	2012	0.5	2.75	5
DR Congo	2	3.8	15.0	26.3	100	0	2010			
Equatorial Guinea	1	0.1	0.3	0.5	100	0	2010			
Ethiopia	1	0.1	0.3	0.5	100	0	2010			
Gabon	1	0.1	0.3	0.5	100	0	2010		0 ***	
Gambia	1	0.1	0.3	0.5	100	0	1996		****	
Ghana	4	49.0	70.0	91.0	100	0	2010	49.0	70.0	91.0
Guinea	3	0.2	0.3	0.5	100	0	2002			
Guinea-Bissau	1	0.1	0.3	0.5	100	0	2002			
Kenya	2	1.9	7.5	13.1	100	0	2002	1	3.5	6
Lesotho	1	0.1	0.3	0.5	100	0	2002		0 ****	
Liberia	1	0.1	0.3	0.5	100	0	2003			
Madagascar	2	0.4	1.5	2.6	100	0	2003			
Malawi	1	0.1	0.3	0.5	100	0	2001		0 ****	
Mali	4	14.0	20.0	26.0	100	0	2011	5	12.5	20
Mauritania	1	0.1	0.3	0.5	100	0	2004			
Mozambique	3	2.0	4.0	6.0	100	0	2009			
Niger	1	0.1	0.3	0.5	100	0	2000			
Nigeria	3	10.0	20.0	30.0	100	0	2011			
Rwanda	1	0.1	0.3	0.5	100	0	1992			
Senegal	2	0.4	1.5	2.6	100	0	2010	2.6	5.2	7.7
Sierra Leone	1	0.1	0.3	0.5	100	0	2004	2	11	20
South Africa	2	1.9	7.5	13.1	50	50	2005	1	3.5	6

Country	Data from Global Mercury Assessment 2013							Re-evaluated estimates from this study*		
	Quality of data <sup>a</sup>	Mercury consumption, t/year			Percentage of total Hg applied to concentrate amalgamation *	Percentage of total Hg applied to whole ore amalgamation	Year of most recent data	Mercury consumption, t/year		
		min	mean	max				min	mean	max
Sudan	3	30.0	60.0	90.0	100	0	2011	63	83	103
South Sudan								0	0	0
Swaziland								0.1	0.3 **	0.5
Tanzania	4	31.5	45.0	58.5	100	0	2009	30	42.5	55
Togo	2	1.0	4.0	7.0	100	0	2002			
Uganda	3	0.4	0.8	1.2	100	0	2008	2	4	6
Zambia	1	0.1	0.3	0.5	100	0	2008			
Zimbabwe	3	12.5	25.0	37.5	20	80*****	2009	12.5	25.0	37.5
Total *****		187	327	467				205	351	496

a Class 1 = presence/absence, no quantitative information, error can be greater than  $\pm 100\%$ ; class 2 = some indication of quantity of Hg used, estimated average error  $\pm 75\%$ ; class 3 = quantitative data but not significantly updated within past five years, error  $\pm 50\%$ ; class 4 = recent quantitative data; error  $\pm 30\%$

\* See the main text for the background for the estimates. For countries with no update, the data from the Global Mercury Assessment is used as best estimate.

\*\* According to questionnaire response mercury is used but no data are available on mercury use for ASGM in the country.

\*\*\* According to questionnaire response 2000 miners are involved in mercury-based ASGM activities, but no data on mercury consumption is available.

\*\*\*\* According to questionnaire response mercury is not used for ASGM in the country

\*\*\*\*\* For countries with no indication for 2005, the estimates from the Global Mercury Assessment are used and included in the total.

\*\*\*\*\* The split between whole ore amalgamation and amalgamation from concentrate is 30 - 70 today.

### Available data on number of miners involved in ASGM

Available data on numbers of miners involved in ASGM reported are included in Table 3.2. The table summarizes data obtained from the literature, from questionnaire responses and from the country reports for the 8 participating countries.

The term "Miners" seems to be used different in different surveys and is most often not well defined. In a narrow definition, miners are those people directly involved in the extraction of the ores. This narrow definition is e.g. used in the guidelines for inventories of mercury use in ASGM which distinguishes between miners, pro-

cessors and concession holders (Persaud and Telmer, 2015). More broadly, miners may be those people involved in the extracting and processing of the ore as well as the managers of the mining sites. In workshop discussions as part of this project, most participants would tend to define "miners" using this broader definition. In some surveys, however, it seems that the term is used even broader also including those people providing different services (e.g. food) to the mine workers. Beside the differences in definitions of "miners", surveys of number of miners may also differ as to the methodology for counting how many people are involved in mining activities, as many miners are only part time involved in these activities.

**Table 3.2**  
*Reported data on number of miners involved in ASGM*

Country	Reported number of ASGM miners	Year	Source	Mercury use
Angola	-			
Benin	-			
Botswana	no data	2016	Questionnaire response	
Burkina Faso	200,000	2013	AMAP/UNEP, 2013b	Yes
Burundi	5,000-10,000	2014	Fritz, 2014**	Yes
Cameroun	10,000-30,000	2014	Fritz, 2014	Yes
Central African Republic	400,000 (seems to include those dependent on the ASGM)	2016	Questionnaire response	Yes
	80,000-100,000 (total for gold and diamonds)	2013	Matthysen and Clarkson (2013)	Yes
Chad	no data	2016	Questionnaire response	
Congo	-			
Cote d'Ivoire	30,000-50,000	2014	Fritz, 2014	Yes
DR Congo	300,000	2011	UNEP (2011)	Yes
	600,000	2013	UNEP (2013b)	Yes
Equatorial Guinea	-			
Ethiopia	300,000 - 350,000	2013	UNEP (2013b)	
Ethiopia	500,000	2011	UNEP (2011)	No
Gabon	2,000	2016	Questionnaire response	Yes
The Gambia	No data - activities in border regions	2016	Questionnaire response	Yes
Ghana	1,000,000	2013	UNEP (2013b)	Yes
Guinea	-			
Guinea-Bissau	-			
Kenya	20,000	2016	Questionnaire response	Yes
Lesotho	-			

Liberia	30,000 - 45,000	2011	UNEP (2011)	
Madagascar	-			
Malawi	0	2016	Questionnaire response	Yes
Mali	400,000	2013	UNEP (2013b), ARM estimate*	Yes
Mali	200,000	2016	Questionnaire response	Reported that approximately 50% use mercury
Mauritania	-			
Mauritius	0	2016	Questionnaire response	Yes
Mozambique	100,000	2011	UNEP, 2011	Yes
	150,000	2013	USGS Minerals Yearbook	Yes
Niger	-			
Nigeria	200,000	2011	UNEP, 2011	Yes
Rwanda	-			
Sao Tome and Principe	0	2016	Questionnaire response	Yes
Senegal	20,000 - 50,000	2013	UNEP (2013b), country representation	Yes
	70,000	2013	UNEP (2013b), ARM estimate *	Yes
	34,000 - 99,000	2014	Persaud, 2014	Yes
Sierra Leone	200,000-400,000	2016	Questionnaire response	Reported that mercury is used by 50% of the miners
South Africa	-			
Sudan	>1,000,000	2015	Ibrahim (2015)	Yes
South Sudan	>60,000	2016	Cordaid (2016)	Reported that mercury is not used (Cordaid, 2016)
Swaziland	no data	2016	Questionnaire response	
Tanzania	>800,000	2013	UNEP (2013b)	Yes
	400,000	2011	UNEP (2011)	
	391,000	2015	MTL, unpublished draft	Majority with Hg use
Togo	-			
Uganda	40,000	2016	This study	Yes
Zambia	-			
Zimbabwe	≥500,000	2015	PACT, 2015	Yes
Total reported/estimated (rounded) *	5-7 million			

\* The total use - the most recent estimate for each country

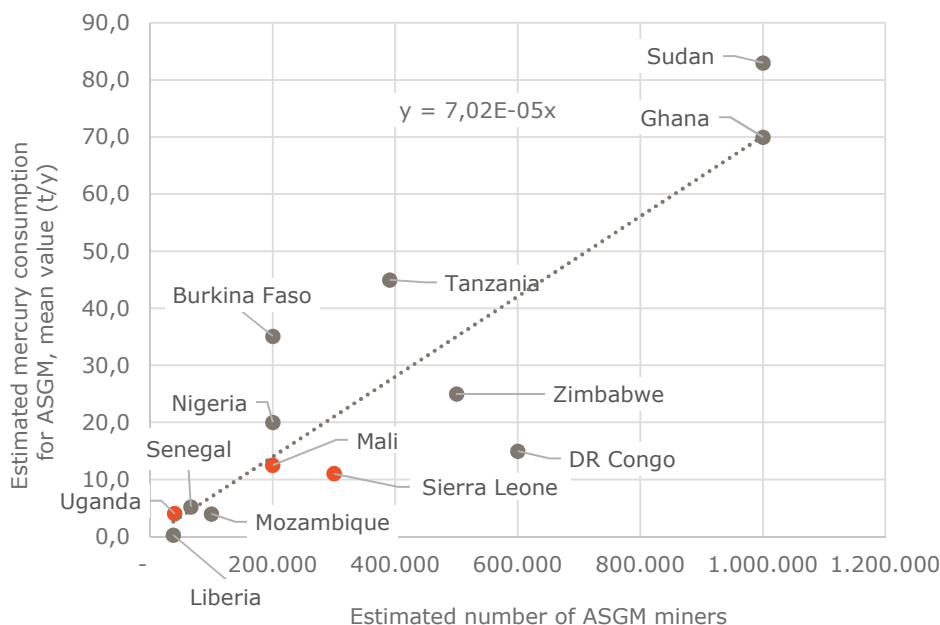
\*\* Results of questionnaire prepared by Fritz (2014)

In order to provide an overview, the estimated consumption of mercury in each country as reported in the Global Mercury Assessment is plotted against the available data on number of miners in each country as reported by country representatives. As the background for the estimates of number of miners in each country is

generally not reported, it is not possible to assess to what extent the two estimates for mercury consumption and number of miners, respectively, are interdependent (e.g. the use of mercury is estimated from the number of miners).

Total correlation is not expected as the mercury use by miner would be dependent on the extraction method, and furthermore the definitions of "miners".

The prevalence of mercury-free methods would result in lower mercury to miner ratios. Mercury free methods include e.g. gold nugget panning of colluvial sediments as described for Senegal (Persaud, 2015).



**Figure 3.4**  
 Estimated mercury consumption for ASGM and estimated number of ASGM miners by country. For countries indicated in orange, mercury consumption has specifically been estimated with a view to the population. This may be true for some of the other values as well, but has not been reported by data sources. The equation represents the linear regression line. The line corresponds to a consumption of 70 g per miner per year.

### 3.1.1 Production, import and export of gold

Industrial-scale gold is usually produced without the use of mercury, whereas mercury is widely used for ASGM. Official data on gold production includes to a large extent only the gold produced at an industrial scale, whereas the trade of gold from ASGM, like the situation for mercury, is often informal.

Appendix 2 presents production and net export of gold in the period 2010-2014 by country. The production data are retrieved from the country reports of the USGS Minerals Yearbook. The production estimates of the USGS Minerals Yearbook is mainly based on information on capacity and production of the industrial mining companies or based on national statistics e.g. from the central banks. The table also includes the information from the Minerals Yearbook on the ASGM in the countries. This information on ASGM is typically included in some notes and cannot be considered comprehensive. This information is typically obtained from the literature and cannot be considered to be independent estimates.

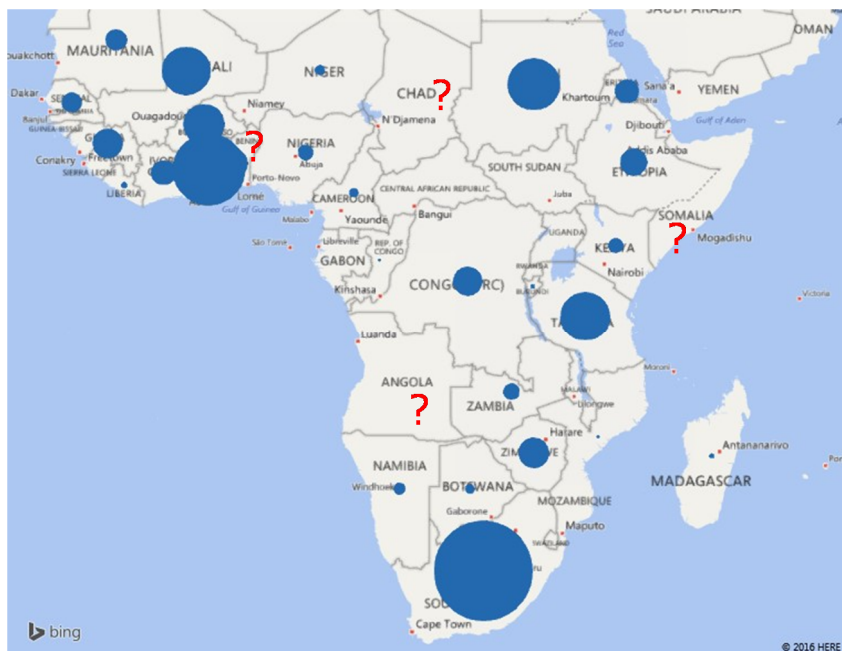
The total recorded gold production increased from 481 tonnes in 2010 to 524 tonnes in 2012.

The net export data (export minus import) were retrieved from the UN Comtrade database (commodity code 7108). For most countries no import is reported and net export is consequently equal to the reported export.

The reported net export is much higher and the data appears to be flawed. Consequently, it is not possible to draw any conclusions on gold production by ASGM by subtracting the reported industrial production from the reported net export.

The distribution of the reported gold production across Sub-Saharan Africa is illustrated in Figure 3.5. The major gold producing countries are Mali, Burkina Faso, Ghana, Sudan, Tanzania, Zimbabwe and South Africa. Comparing with the data for mercury use for ASGM shows that both industrial-scale gold production and ASGM take place in all countries with significant gold production. South Africa stands out with relatively minor

gold production by ASGM while the country is the major producer of gold in the region.



**Figure 3.5**  
Reported gold production in 2013 according to the country reports from US Geological Survey. The reported gold production is mainly industrial. The area of circles indicates the produced quantities. See appendix 2 for further details.

A question mark indicates that no data are available, but USGS notes that they probably have gold production.

### 3.2 Use of mercury for other applications in Sub-Saharan Africa

#### Mercury-added products

The estimated use of mercury for ASGM in the region is significantly higher than the estimated total mercury content of mercury-added products sold in the region as shown in the table below. The total mercury content of products sold in 2010 in the region was estimated in the Global Mercury Assessment at 34 t/year (AMAP/UNEP, 2013). The estimate is derived from information about the global consumption of mercury for production of various mercury-added products, and the products are distributed regionally on the basis of economic activities and other parameters. This approach is considered to result in fairly robust estimates even though the actual uncertainties are probably higher than indicated in the assessment.

Furthermore, as part of this study, the amount of mercury in mercury-added products has been estimated using the approach of the UNEP Mercury Toolkit, whereby the consumption of mercury in products has been estimated for each country in the region and a

total for the region has been derived based on these figures. For batteries, the estimated import of mercury with the products is much higher than the estimate from the Global Mercury Assessment, but the estimate is considered to be unrealistically high, likely due to erroneous entries in the statistics and perhaps ongoing mercury substitution as part of a global trend. The total estimate using the UNEP Mercury Toolkit, if batteries are excluded, is 64 t/year or about twice the estimate in the Global Mercury Assessment. More than half of this is estimated to be in mercury containing electrical switches and relays for which the toolkit default emission factors are highly uncertain and range a factor of hundred from 0.02 to 0.25 g mercury per inhabitant (here the average is applied).

Of the 28-38 t/year (from the Global Mercury Assessment), 15 t/year in measuring devices and electrical devices (where mercury is present as liquid mercury) may potentially be collected in the disposal phase and readily reused for ASGM. The mercury from other applications may in principle be recovered and sold for use in ASGM, but this requires particular equipment for recovery. The data indicate that mercury recovered

from products would account for a minor part of the mercury supplied to the ASGM sector at a regional level.

ucts in Sub-Saharan Africa. It cannot be excluded that some production, e.g. production of batteries or low-tech production of mercury switches, takes place.

As mentioned below, no information is available on facilities for industrial production of mercury-added prod-

**Table 3.3**

*Estimated content of mercury in mercury-added products sold in Sub-Saharan Africa in 2010 (AMAP/UNEP, 2013)*

	Estimated mercury content, t/year (based on AMAP/UNEP, 2013)		Alternative estimate based on import statistics and default factors from the UNEP Mercury Toolkit
	Mean	Range	
Batteries	4	3-5	<p>Average yearly net import for the period of 2010 – 2014 of mercury oxide batteries is 6,338 t and for other batteries containing mercury (i.e. silver oxide cells, zinc-air cells and alkaline cells other than button cells), the corresponding figure is 80,534 t according to import and export data in the Comtrade database. Using the calculation method in the UNEP Mercury Toolkit, mercury oxide batteries contribute 2,028 t, while the remaining batteries add up to 43 t mercury, resulting in 2,071 t/year mercury in total.</p> <p>This estimate is highly unrealistic, and is presumably a results of erroneous entries in the trade database. Gambia e.g. reports average yearly net import for the period of 2010 – 2014 of mercury oxide batteries of 4,638 tonnes, thus contributing 73% to mercury from mercury oxide batteries.</p>
Measuring devices (thermometers, barometers, etc.)	9	8-10	Other manometers and gauges with mercury (excluding thermometers) estimated at 1.3 t/year based on the methodology used in the UNEP Mercury Toolkit. No data for thermometers which require actual data from countries.
Lamps	4	3-4	Average yearly net import for the period of 2010 – 2014 of lamps containing mercury (i.e. fluorescent tubes, high pressure mercury and sodium lamps, metal halide lamps and UV-light) is about 62 million items according to import and export data in the Comtrade database. Using the calculation method in the UNEP Mercury Toolkit, fluorescent tubes (double and single end) contribute 1,007 kg mercury, while the remaining lamps add up to 103 kg mercury, resulting in a total mercury content of 1.1 t/year.
Electrical devices	6	5-7	Electrical switches and relays with mercury estimated at 35.9 t/year (6-70 t/y) based on the methodology used in the UNEP Mercury Toolkit
Dental amalgams	6	5-7	Estimated at 5.3 t/year based on the methodology used in the UNEP Mercury Toolkit
Other use*	5	4-5	<p>Polyurethane (PU, PUR) produced with a mercury catalyst estimated at 7.7 t/year based on the methodology used in the UNEP Mercury Toolkit</p> <p>Laboratory chemicals estimated at 2.6 t/year based on the methodology used in the UNEP Mercury Toolkit</p> <p>Other laboratory and medical equipment with mercury estimated at 10.3 t/year based on the methodology used in the UNEP Mercury Toolkit</p>
<b>Total</b>	<b>34</b>	<b>28-38</b>	

\* The 'other use' category includes, for example, pesticides, fungicides, laboratory chemicals, polyurethane elastomers, pharmaceuticals, preservative in paints, traditional medicines, cultural and ritual uses, cosmetics – especially skin-lightening creams, etc.

A UNEP report on excess mercury supply in Latin America and the Caribbean estimates that in 2005, 3% of mercury in mercury-added products in Latin America and the Caribbean was recycled (UNEP, 2009). Recycled products include in particular blood pressure instruments used in health clinics, dental wastes and button cell batteries. The report further assumes that the percentage will increase to 10% of consumption by

2020, and 25% by 2040. If it is assumed that 3-10% of the mercury in mercury-added products are currently recycled in Sub-Saharan Africa, the total quantity of recycled mercury placed on the market would be 1-3 t/year. Even though it could be a significant source locally, at a regional level the recycling of mercury from mercury-added products would only account for approximately 1% of the supply.

## Industrial production of mercury-added products and mercury use in industrial processes

**Chlor-alkali** - Only one chlor-alkali plant using the mercury method is located in Sub-Saharan Africa. According to UNEP (2013a) in 2010, about 10,000 tonnes  $\text{Cl}_2$  were produced at this plant in Angola. The plant is listed in the Global Inventory of Mercury-Cell Chlor-Alkali Facilities (2013 update), but without any data on mercury use and emissions or data on mercury stored on the site. An indication of the amount of mercury purchased annually for the plant can be obtained by using the reported capacity of 10,000 tonnes  $\text{Cl}_2$  and the default input factor from the UNEP Mercury Toolkit. Using the Toolkit, the annual mercury consumption for the plant in Angola can be estimated at approximately 1,000 kg. No import data for mercury is available for Angola, but during the period 2010-2014, partner countries have recorded a total mercury export to Angola of 81 kg.

No data on the mercury accumulated in the cells are available. In the EU, on average 2.08 tonnes per 1000 tonnes  $\text{Cl}_2$  capacity was accumulated in the cells of mercury cell chlor-alkali plants (Zettl et al., 2015). If this figure is applied to the plant in Angola, the total amount of mercury accumulated would be approximately 21 tonnes. When, sometime in the future, the plant is decommissioned, this mercury may be placed on the market. Compared to the total import of mercury to the region, the decommissioning of the plant would however only have a small impact on the overall flow of mercury in the region.

On the African continent chlor-alkali plants exist in Algeria (2 facilities of 14,000 t/year chlorine capacity in 2012), Libya (1 facility of a capacity of 45,000 t/year in 2012), Morocco (1 facility of a capacity of 45,000 t/year in 2012). Using the average figure for mercury per 1000 tonnes  $\text{Cl}_2$  capacity, in total some 216 tonnes mercury may be accumulated in these facilities.

One trading company in South Africa informed the study that mercury has been imported from Algeria and

that the origin of the mercury was a chlor-alkali plant. This makes it likely that some mercury from chlor-alkali plants in Algeria, Libya and Morocco (e.g. from stocks stored at the plants) also may be transported by truck through the Sahara to countries in central and western Africa.

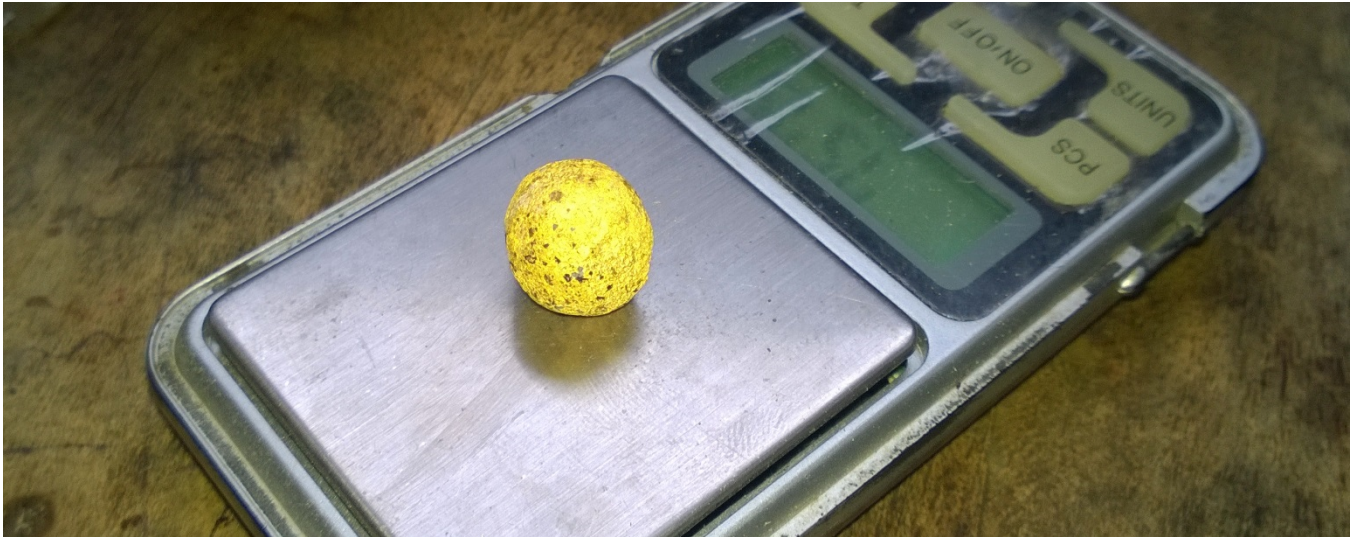
The national mercury inventory for Kenya states that a chlor-alkali plant may have been in operation in the past for production of chlorine for the Webuye Pulp and Paper Mills. The inventory mentions that it has been reported that the chlor-alkali process is no longer used in Kenya and elemental chlorine is no longer used for bleaching pulp and paper.

**Other industrial processes** –In the 11 national mercury inventories, which are published on UNEP's Mercury Toolkit website, several countries assign a question mark for mercury consumption for some industrial uses. Among the uses indicated with a question mark are VCM production with mercury catalyst (Cameroon), acetaldehyde production with mercury catalyst (Cameroon), batteries with mercury (Kenya, Nigeria), biocides and pesticides with mercury (Cameroon, Nigeria), electrical switches and relays with mercury (Ethiopia), paints with mercury (Cameroon, Ethiopia, Kenya, Nigeria), and skin lightening creams and soaps with mercury chemicals (Ethiopia, Kenya, Nigeria). The inventories are undertaken in accordance with Level 1 of the mercury toolkit and may indicate that the knowledge level in the country as regards the use of mercury is limited.

Only the national mercury inventory of Kenya lists quantified estimates for the consumption of mercury for the production of batteries, paints with mercury, and skin lightening creams and soaps. The use of mercury for their manufacture is indicated as "suspected" with no further details. Each of these uses is estimated at 1,000 kg each, resulting in a total estimated industrial consumption of 3,000 kg mercury per year.

The total use of mercury for industrial production in Senegal is reported at 106 kg for production of batteries in one factory. The estimate is based on current information from the factory.





## 4 Regulation of mercury trade and use in ASGM

The current section presents an overview of the legal status of mercury trade and mercury use in ASGM in the countries in Sub-Saharan Africa. Furthermore, a more detailed description for each of the 8 participating countries is provided.

### 4.1.1 License systems

**License system for mercury trade** - Many countries with mercury use in ASGM have a license system for trade with mercury. This concerns e.g. Tanzania, Senegal, Burkina Faso, Zimbabwe, Ghana, Kenya and South Africa. In all the countries apart from South Africa, however, a very small part of the total trade of mercury is undertaken by companies with a license and registered by the authorities. Detailed data on all import permissions obtained in Ghana, Senegal and Zimbabwe for the last ten years have been obtained from the authorities in the countries. For Ghana and Senegal it is characteristic that the companies during this period all has obtained one permit only indicating that the importing companies only import mercury occasionally and are not further involved in mercury trade. In Senegal, permits for import of mercury have not been issued the last five years. In Burkina Faso, so far no permits have been issued. As the enforcement of the license systems is very difficult for reasons described elsewhere in this report, the importers apparently have no incentives for using time and resources on obtaining permits.

**License system for mercury use in ASGM** - In the major ASGM countries, the use of mercury in ASGM is

legal and there is no requirement for a license specifically for the use of mercury. In Tanzania mercury use in ASGM is legal, provided that retorts are used, which according to the available information is very uncommon. Some countries distinguish between artisanal mining and small-scale mining. In Burkina Faso and Côte d'Ivoire, mercury is prohibited in artisanal mining (artisanal is defined differently in the two countries) whereas it can legally be used in small-scale mining, provided the miners have the necessary license.

### 4.1.2 Systems in participating countries

**Burkina Faso** - In Burkina Faso the law # 036 -2015/ CNT related to Mining Act, article 77 reveals that: "It is prohibited to use explosives, hazardous chemicals, especially cyanide and mercury in activities related to artisanal mining". Mercury is allowed for use in small-scale mining and a license for import or trade of mercury is required. The import license is issued by the ministry in charge of mines. According to obtained information, no licenses has so far been issued.

**Côte d'Ivoire** - Since 31 March 2014 artisanal mining is divided into two categories:

- › The Artisanal mining for which the license is delivered for a square of 25 Hectares and the shaft may not be deeper than 15 meters.
- › The semi industrial or medium-size mine for which the license is delivered for a square of 100 hec-

tares maximum and the shaft may not be deeper than 30 meters.

For artisanal mines, no mercury or other chemicals are allowed for use. Medium size mines will, however, be allowed to use mercury or cyanide. But for that purpose, the company or the mine owner needs to present his management plan for destruction or treatment of wastes generated by chemicals use. This plan needs to be accepted both by ministries in charge of environment and the one in charge of mines. After the license is signed by the ministry of mines, the company will be allowed to buy mercury or chemicals needed for its activities. In 2016, the ministry of mines started signing licenses for medium size-mines.

**DR Congo** - The Mining Regulations ('Réglement Minier', April 2003) in article 238 (discussing the authorisation required for processing of artisanal mining products) stipulates that only organizations having authorisation from the government are allowed to use mercury, cyanide or other dangerous chemicals. If an individual artisanal miner uses one of these products, the government will revoke his mining license. In article 575 of the same Mining Regulations, it states that the use of mercury is strictly forbidden in artisanal gold mining. However, gravity methods and other methods that do not use chemicals, which are harmful to ecosystems, are allowed.

During field work poor enforcement of these laws has been observed. In the Kamituga district, for example, there is no organization with the license to exploit mercury (that can be delivered only by the Ministry of Environment), but everybody is aware that mercury is being used.

According to the Mining Code, artisanal miners can only sell their production to registered traders holding a 'carte de négociant' issued by the Provincial Governor. These traders may sell to registered buyers who are associated with an export office.

**Ghana** - Mercury is governed by the Mercury Act, 1989, which grants power to the Ministry of Trade and Industry to regulate mercury. Upon applications and endorsements from the Environmental Protection Agency (EPA) and the Minerals Commission, applicants may be granted an import permit with a 6 month validity. In the whole of 2015, one permit was issued for an import of 172.5 kg of mercury, indicating rampant smuggling. Use of mercury for ASGM is legal.

**Senegal** – The Department of Environment is the institution responsible for carrying out the process of issuing authorization for mercury imports. Importers should declare to Customs that they are importing hazardous substances, and apply to the Department of Environment for the authorization. But, to date, the department has never received an application for mercury import for industrial or commercial purposes. Mercury use for ASGM is not prohibited. The National Commission on Chemicals Control decided not to prohibit mercury in order to be more able to handle the problem and adopt a step by step strategy to reduce its use.

According to Persaud (2015) there is no explicit law against mercury use in the ASGM sector in Senegal, and it is not mentioned in the national mining code, however it is considered de facto illegal by miners and local authorities of Kedougou, the main mining area. This state of illegality is the result of 1) an article of the Environmental Code, which says that noxious and dangerous chemicals that present or may present a danger to humans or the environment, are subject to the control and supervision of relevant departments and 2) national government edict n° 2010-1281, which prohibits the importation, collection, transportation, recycling, storage, manipulation, treatment or elimination of mercury without Ministerial approval. According to Persaud (2015) it is certain that no person or group involved in the ASGM sector has received such approval.

**Tanzania** - The Industrial and Consumer Chemicals (Management & Control) Act No. 3 of 2003 through the Government Chemist Laboratory Agency (GCLA) regulates the production, importation, exportation, transportation, storage and dealing of mercury and other chemicals in Tanzania. As per Section 9 of the Act, the Chief Government Chemist is the Registrar of Industrial and Consumer Chemical in Mainland Tanzania. In order to ensure control of production, importation, exportation, transportation, storage and dealing of mercury or any other chemical, an application for registration of chemicals needs to be made to the Chief Government Chemist in the prescribed manner and form, and accompanied by prescribed fees as set out in the Act. The registration procedures are clearly set out in Section 11 to 29 of the Act. After an application is submitted, the Registrar will conduct the necessary investigation before approval by the board of the GCLA. As such, every chemical (including mercury) which is imported, distributed, manufactured, transported, sold, or stored shall bear on its container a label with the words "Approved

by the board", Chemical Abstracts Service (CAS) and registration number, batch number and dates of manufacture, expiry, trade and chemical name, etc. The registration period for a chemical shall be five years with two years for provisional registration. The Mining Act of 2010 allows for the use of mercury subject to the use of retort when burning amalgam.

**Uganda** - Mercury is not mentioned in recent mining and environment legislations. However, according to the Ugandan authorities new legislation is soon to be published and the revised Environmental Act is likely to present legislation related to mercury.

**Zimbabwe** - Mercury is not banned in Zimbabwe, but its usage is restricted and discouraged. While mercury import was previously conducted by a number of formal companies dealing with import of mining equipment and

chemicals, in recent years this has been restricted by the Ministry of Environment, which cancelled the licenses of these companies and has presently only issued one license to a company based in Bulawayo. This company has to submit quarterly reports on imported quantities and records of which buyers they sell to. However, the restriction of mercury sale to one company may have resulted in increased smuggling of the substance into Zimbabwe, as buyers have fewer outlets in which they can formally buy mercury. This is reflected in a steep decline in the officially registered import of mercury and increase in the informal import.

### 4.1.3 Overview of legal status

An overview of the legal status for mercury trade and mercury use in ASGM in countries in Sub-Saharan Africa is provided in Table 4.1..

Table 4.1 Legal status for mercury trade and mercury use in ASGM

	Mercury trade Legal status	Mercury use in ASGM, as indicated by information source Legal status	Mercury used for ASGM	ASGM activities	Information source
Angola					
Benin					
Botswana	Not indicated	Not indicated	indicated by a ?	+	Questionnaire
Burkina Faso	License system	Legal in small-scale mining, Illegal in artisanal	Yes	Yes	Interviews with stakeholders
Burundi					
Cabo Verde					
Cameroon	Not restricted, no license system	-	No	No	Questionnaire
Central African Rep	License system	Legal	Yes	Yes	Questionnaire
Chad	Not restricted, no license system	Legal, license	Yes	Yes	Questionnaire
Comoros					
Congo					
DR Congo	Not restricted	License system; restricted (legislation seems to be contradictory)	Yes	Yes	Interviews with stakeholders
Cote d'Ivoire	License system	Legal in small-scale mining, Illegal in artisanal	Yes	Yes	Interviews with stakeholders
Djibouti					
Equatorial Guinea					
Eritrea					

	Mercury trade	Mercury use in ASGM, as indicated by information source			Information source
	Legal status	Legal status	Mercury used for ASGM	ASGM activities	
Ethiopia					
Gabon	License system, restricted to specific uses	Prohibited	Yes	Yes	Questionnaire
Gambia	No regulations	No regulations	Yes	Yes	Questionnaire
Ghana	License system	Legal	Yes	Yes	Interviews with stakeholders
Guinea					
Guinea-Bissau					
Kenya	License system	Legal	Yes	Yes	Questionnaire
Lesotho	License system	-	No	No	Questionnaire
Madagascar					
Malawi	Not indicated	-	No	No	Questionnaire
Mali	License system	Prohibited	Yes	Yes	Questionnaire
Mauritania					
Mauritius	License system, restricted to specific uses	-	No	No	Questionnaire
Mozambique					
Namibia					
Niger					
Nigeria	Not indicated	Legal	Yes	Yes	Eli, 2014
Réunion					
Rwanda					
Sao Tome & Principe	Not restricted, no license system	-	No	No	Questionnaire
Seychelles					
Sierra Leone	Not restricted, no license system	Legal	Yes	Yes	Questionnaire
Senegal	License system	Legal	Yes	Yes	Interviews with stakeholders
Somalia					
South Africa					
South Sudan					
Sudan					
Swaziland	Not restricted, no license system	Legal	Yes	Yes	Questionnaire
Togo					
Uganda					
United Rep. of Tanzania	License system	Legal, if retorts are used	Yes	Yes	Interviews with stakeholders
Zambia					
Zimbabwe	License system	Legal, but dis-	Yes	Yes	Interviews with stakeholders

Mercury trade	Mercury use in ASGM, as indicated by information source			Information source
Legal status	Legal status	Mercury used for ASGM	ASGM activities	
	couraged			



## 5 Environmental and health perspectives

### 5.1 Human exposure and health effects

Mercury exposure and health impacts among individuals in the ASGM community have been reviewed by the World Health Organization (WHO, 2013) and the information below, unless otherwise specifically indicated, is extracted from this review (please consult the review for the original reference).

#### 5.1.1 Significance of mercury exposure in ASGM communities

Much of the available literature regarding mercury exposure among ASGM communities, miners and communities affected by ASGM, examines mercury levels in hair. Hair concentrations correlate with dietary methylmercury intake. Other biological matrices where mercury is measured include urine and blood. Blood mercury concentrations characterize recent or current exposure and can represent both elemental and methylmercury exposure while urinary mercury reflects elemental and inorganic mercury exposures.

Individuals residing in or near ASGM communities are typically exposed to:

- › methylmercury-contaminated fish or
- › the mercury vapor produced during the amalgam burning process.

Urinary mercury among those who heat mercury to remove it from the gold or who amalgamate the gold with mercury can be extraordinarily elevated. Many studies report urinary mercury concentrations well above 50 µg

mercury/g-creatinine, a urinary concentration where renal tubular effects are believed to occur, and/or 100 µg mercury/g-creatinine, a urinary concentration where the probability of developing the classical neurological signs of mercury intoxication is "high". Even those who simply reside in ASGM areas, including children, have been reported to have urinary mercury concentrations higher than 100 µg mercury/g-creatinine.

Persons living downstream of ASGM operations have been found to have hair mercury concentrations that are more than ten times the hair mercury concentration (2.5 µg mercury/g) associated with the Provisional Tolerable Weekly Intake (PTWI). The PTWI for methylmercury was established by the FAO/WHO Joint Expert Committee on Food Additives (JECFA).

#### 5.1.2 Mercury health effects

Elemental and methylmercury are toxic to the central and peripheral nervous system. The inhalation of mercury vapor can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal.

Neurological symptoms include mental retardation, seizures, vision and hearing loss, delayed development, language disorders and memory loss.

In children, a syndrome characterized by red and painful extremities called acrodynia has been reported to result from chronic mercury exposure.

### 5.1.3 Demonstrated mercury health effects in ASGM communities

The current epidemiological literature regarding health impacts from mercury exposure in ASGM communities consists of cross-sectional studies in multiple countries on three continents – South America, Asia, and Africa. The main health outcomes examined in these studies include neurological disorders, kidney dysfunction, and immunotoxicity/autoimmune dysfunction.

#### Neurological Disorders and Symptoms

Several studies examining children in ASGM communities have found associations between mercury levels and increased deep tendon reflexes, poor leg coordination, decreased performance on visuospatial organization tests, and reduction in motor function, attention, visual contrast sensitivity and manual dexterity.

A study of Philippine children residing near a gold mill and processing plant reported significant adverse neurological findings.

A study conducted in Burkina Faso found that the prevalence of symptoms, including frequent headaches, sleep disorder, unusual tiredness, trembling, and vision disorder, was increased among individuals involved in either mercury-gold amalgamation and heating of the amalgam or gold dealing and selling.

A study among gold miners in Ecuador reported an association between blood and urinary mercury levels and an increase in tremor, reaction time and postural stability.

Investigators that conducted a study in the Tapajos River basin in Amazonian Brazil diagnosed three individuals with mild Minamata disease and suspected Minamata disease in three other individuals.

#### Kidney Dysfunction

Exposure to high levels of elemental mercury has been associated with kidney effects. Two studies have found an association between mercury concentrations and kidney dysfunction or kidney microdamage in residents of ASGM communities.

#### Immunotoxicity/autoimmune dysfunction

Four studies report an association between methylmercury exposure and autoimmune dysfunction in mining communities in Amazonian Brazil.

#### Example: Zimbabwe

PACT (2015) findings suggested that Zimbabwe has some of the world's highest levels of mercury pollution and human exposure to toxic risks. In a sample of miners examined for mercury poisoning in a study in the Insiza Mining District, 60% of the population had general body weakness, 55 percent had nausea, 50% had lost teeth, 45% had a history of respiratory distress, 40% had high salivation and tremors, 40% had high mercury levels in hair, and 30% had high mercury levels in their blood. These symptoms were associated with occupational mercury poisoning (PACT 2015).

According to Bose-O'Reilly et al. (2008, as cited by Gibb and O'Leary, 2014), 29% of children living in Hg-exposed areas in Zimbabwe were considered intoxicated. Fifty-five percent of children working with Hg in Zimbabwe were considered intoxicated. None of the control children were considered intoxicated.

#### Example: Tanzania

Hilson and Maduba (2014) reviewed health impacts on ASGM miners in Tanzania. According to the authors, there is evidence of high levels of exposure to mercury pollution among communities in the Geita district, which is the main ASGM district in Tanzania. According to the authors (the following is mainly a direct citation from Hilson and Maduba, 2014), a study undertaken in 2003 found that persons living in and/ or miners working in highly exposed areas have significantly higher concentration of total mercury in urine, hair and blood as compared to the non-exposed control group. Mercury exposure has directly led to serious health hazards in the small-scale gold mining area of Rwamagasa. Another study involving testing of water, soil, sediments and fish samples was undertaken in August 2003 in the Rwamagasa artisanal gold mining area in the Geita District which has about 30 groups of historic and active tailings dumps. The area also has about ten localities where mercury amalgam is burned in a small charcoal fire. The study concluded that many years of working in the amalgamation process, especially in amalgam burning, results in severe symptoms of mercury intoxication. The exposure of the whole community to mercury is reflected in raised mercury levels in urine, and the detection of the first symptoms of brain damage such as ataxia, tremor and movement disorders. Mercury intoxication was diagnosed in 25% of the amalgam burners from Rwamagasa. In addition, intoxication was also detected in some people that had formerly worked with mercury and amalgam. People from Rwamagasa

who are not directly involved in amalgam burning have a higher mercury burden than the control group, although the majority of these people are not intoxicated. The background mercury burden in the Katoro control group is of the same order of magnitude as in Western industrial countries.

Impact on children is relatively higher, particularly on their learning ability. A report from August 2013 that examined child labor and exposure to mercury in small-scale gold mining in Tanzania, noted that exposure to mercury vapor can cause neurological and developmental problems and it is particularly harmful to children. In some cases, work in mining also affects children's attendance and performance at school and places girls at risk of sexual harassment and exploitation. Child labor in the Rwamagasa mining sites is common from the age of 10. The children work and play with their bare hands with mercury. Extremely high mercury concentrations were detected in two out of five breast-milk samples from nursing mothers who worked as amalgam burners, putting their babies at special risk.

#### Awareness among miners

Several studies from Sub-Saharan Africa have demonstrated that the awareness among the miners of the health and environmental problems caused by mercury is small. As an example, a study in two regions in Zimbabwe, Kadoma and Shurugwi, demonstrated that only 46% of miners knew about the health problems related to mercury, with men (56% in Kadoma and 41% in Shurugwi) appearing to be much more knowledgeable than women (39% in Kadoma and 17% in Shurugwi) (PACT, 2015). There was higher awareness around mercury in Kadoma because of the Global Mercury Project, conducted in the area a decade ago. Nearly 18% of respondents had burned amalgam at home, and only 11% had ever used a retort when burning mercury. Three percent had experienced the kinds of health problems that are associated with mercury exposure.

#### 5.1.4 Overall conclusion

The mercury exposure and health impacts among individuals in artisanal and small-scale gold mining communities has recently been reviewed by Gibb and O'Leary (2014), who reach the conclusion:

"Individuals involved in the gold mining operations, their families, and those in the gold mining communities are exposed to dangerous levels of elemental Hg vapor, as evidenced by urinary Hg concentrations. This evidence

includes extremely elevated urinary Hg concentrations in children who work in the mines and children who live in the areas where small-scale gold mining occurs. Residents in the gold mining communities and downstream of the gold mining communities consume fish that may be heavily contaminated with MeHg, as demonstrated by hair Hg measurements. Current studies indicate that those in the ASGM communities experience neurological effects, kidney effects, and possibly immunotoxic/ autoimmune effects from Hg exposure. Not only is the danger widespread globally, but the problem is expected to grow".

## 5.2 Environmental effects and release sources

The environmental effects of mercury are well described and elevated mercury levels in wildlife have been demonstrated from all over the world. Once released, mercury can travel long distances, and persist in environments where it circulates between air, water, sediments, soil, and living organisms. Mercury is concentrated as it rises up the food chain, reaching its highest level in predatory fish such as swordfish and shark that may be consumed by humans. Consequently, any releases may be regarded as a contribution to the overall global environmental load of mercury. In addition to global impacts, mercury released to the aquatic environment may result in impacts at a local or regional level.

### 5.2.1 Environmental exposure and effects of mercury

The exposure to mercury and the resulting effects were reviewed in the first Global Mercury Assessment (UNEP, 2002) which formed the background for the development of the Minamata Convention. According to the assessment "*elevated methylmercury levels have been measured in numerous freshwater and marine fish species throughout the world. The highest levels are found in large predatory fish and fish-consuming mammals. Exposure studies from diverse geographic areas indicate that a significant portion of humans and wildlife throughout the world are exposed to methylmercury at levels of concern, primarily due to consumption of contaminated fish.*"

Particularly vulnerable ecosystems and wildlife populations include top predators in aquatic food webs (such as fish-eating birds and mammals), Arctic ecosystems,



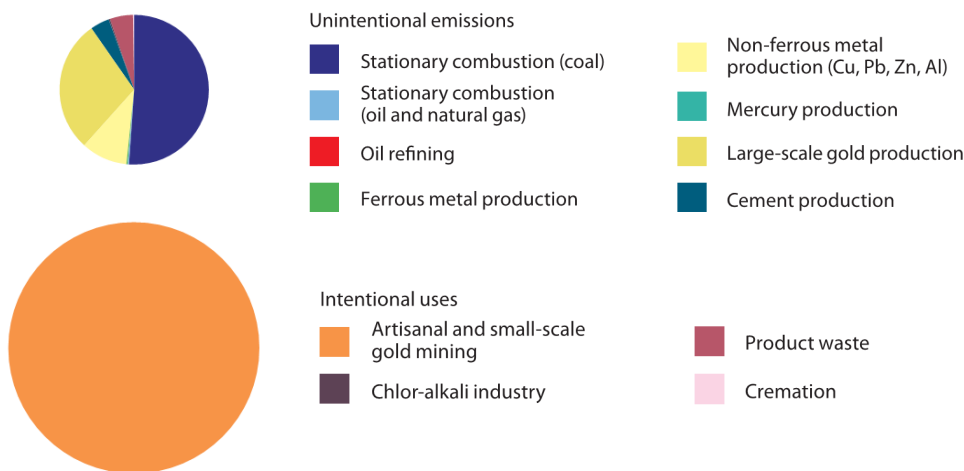
wetlands, tropical ecosystems and soil microbial communities (UNEP, 2002).

According to the assessment: "Numerous wildlife species that rely on fish as a large part of their diet can have elevated mercury levels that raise the risk of adverse effects. Animals with the highest mercury levels include otter, mink, raptors, osprey, and eagles, which are top predators in the aquatic food chain. For example, eggs of certain Canadian bird species have mercury levels that are a threat to reproduction. Moreover, mercury levels in Arctic ringed seals and beluga whales have increased by 2 to 4 times over the last 25 years in some areas of the Canadian Arctic and Greenland. In warmer waters, some predatory marine mammals are also at risk. In addition, recent evidence indicates that soils are adversely affected over large parts of Europe and potentially in many other locations. However, in some environments, even fairly heavy mercury loads have very little effect on organisms as either mercury is not efficiently bioaccumulated throughout the local food

chain or the mercury is not easily methylated. In addition, the effects of watershed management practices in certain locations on methylmercury levels may be more significant than the effects of direct or diffuse mercury inputs" (UNEP, 2002).

### 5.2.2 Emissions to the atmosphere in Sub-Saharan Africa

As illustrated in Figure 5.1, ASGM represent the majority of the mercury emissions from Sub-Saharan Africa. Of an average annual per capita emission to the atmosphere of 0.39 g/year from all activities, 0.29 g/year originated from ASGM activities corresponding to 73% of the total emissions (AMAP/UNEP, 2013). The total atmospheric emission of mercury from Sub-Saharan Africa in 2010 was estimated at 316 t/year (168-514 t/year), representing 16.1% of the total mercury emission. Consequently, ASGM activities in Sub-Saharan Africa are responsible for approximately 12% of the global anthropogenic mercury emissions to the atmosphere.



**Figure 5.1**  
Sources of mercury emissions in Sub-Saharan Africa. The area of the pies indicates the relative contributions from sources. (Based on AMAP/UNEP, 2013)

### 5.2.3 Releases to the aquatic environments and soil

The most recent Global Mercury Assessment (AMAP/UNEP, 2013) estimates that 45% of the mercury released from ASGM activities is released to the atmosphere, mainly by burning of amalgam, while the remaining 55% was released to rivers, lakes, soils and tailings (collectively referred to as the hydrosphere). Results from historical gold rushes suggest that over a period of 100 years, at least 70% of known inputs to the

hydrosphere are subsequently released to the atmosphere.

The share of the release between the different compartments depend on the methods applied in ASGM. Releases to the hydrosphere are higher when whole ore amalgamation is applied, as compared to amalgamation from concentrate. As ASGM in Sub-Saharan Africa is mainly based on amalgamation from concentrate, the share of the total releases going to the hydrosphere is smaller in Sub-Saharan Africa than the global

average. According to the Global Mercury Assessment, 69% of the mercury used for ASGM (230 t/year of 334 t/y) was released to the atmosphere. It is not specifically indicated whether the remaining 104 t/year was released to the hydrosphere, but as the recycling rate is close to zero, this is the most likely pathway.

In the environment the elemental mercury can be transformed into methylmercury, which is far more toxic to

humans and animals and can enter and bio-magnify in food webs more readily than other forms of mercury.

Environmental contamination from the use of mercury in ASGM has been demonstrated in many countries in Sub-Saharan Africa.



## 6 Abbreviations and acronyms

ARM	Alliance for Responsible Mining	KES	Kenyan shilling
ASGM	Artisanal and small-scale gold mining	NAP	National Action Plan (for mercury use in ASGM)
ASM	Artisanal and small-scale mining	SADC	Southern African Development Community
CFA	Name of two currencies used in Africa which are guaranteed by the French treasury: West African and Central African CFA	SAR	Special Administrative Region (in China)
CN	Combined Nomenclature (used in trade statistics)	TZS	Tanzanian shilling
DRC	Democratic Republic of the Congo	UGX	Ugandan shilling
EIA	Environmental Impact Assessment	UN	United Nations
EPA	Environmental Protection Agency	UNEP	United Nations Environment Programme
EU	European Union	UNIDO	United Nations Industrial Development Organization
GMA	Global Mercury Assessment	USD	United States of America dollars
GMP	Global Mercury Project	USGS	United States Geological Survey
GHS	Ghanaian Cedis	WB	World Bank
Hg	Mercury	WHO	World Health Organization

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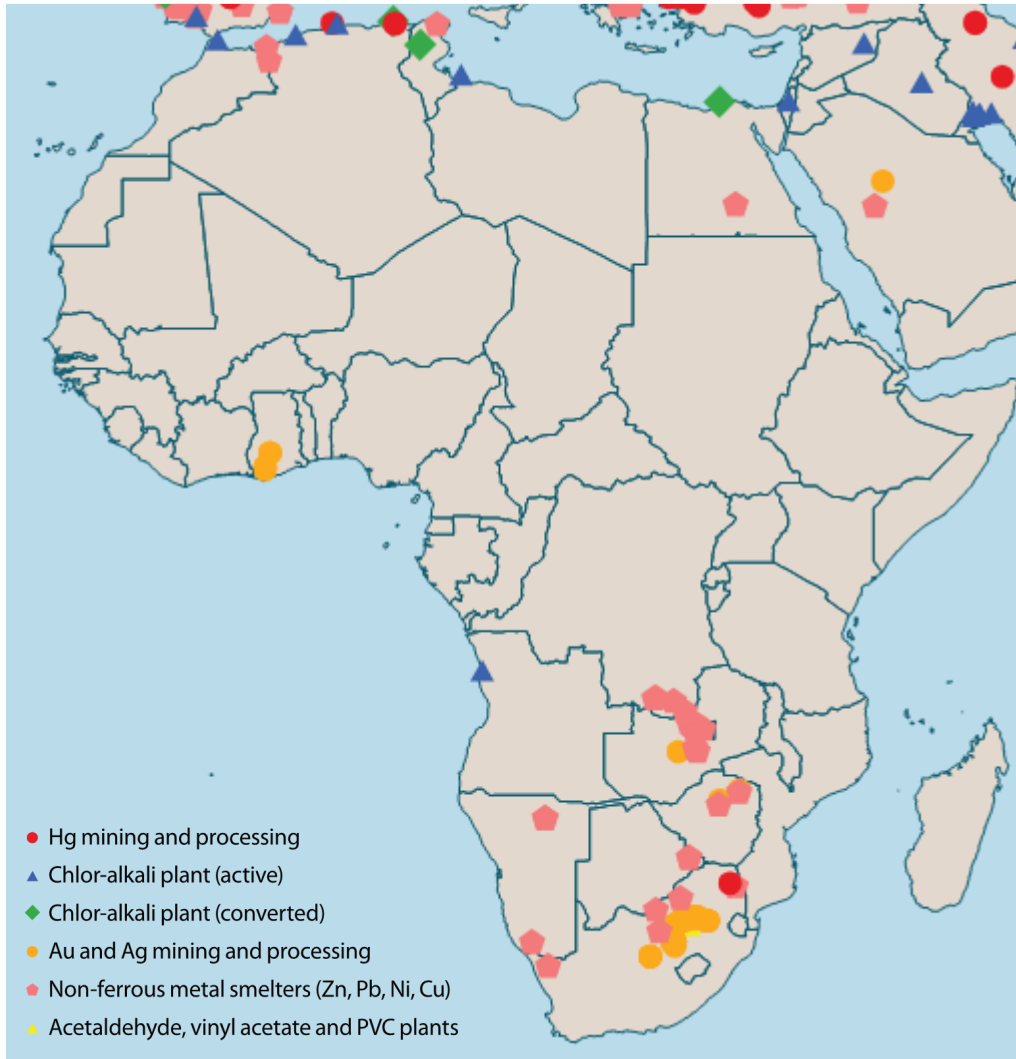
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## Appendix 1: Mercury contaminated sites

Mercury contaminated sites as identified in the Global Mercury Assessment (AMAP/UNEP, 2013) are seen in the below figure. Apart from one chlor-alkali plant in Angola and a former primary mining site in South Africa, the sites in Sub-Saharan Africa are all gold mining and processing and non-ferrous metal smelters where mercury present in the ores is mobilized.



Source: Global Mercury Assessment 2013 (UNEP, 2013).

## Appendix 2: Production of gold in the countries

Production of gold according to USGS Minerals Yearbook for the countries and net export of gold (Code 7108) 2010-2014 by country is shown in the table overleaf.



	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **				
	2010	2011	2012	2013				2010	2011	2012	2013	2014
Angola	nd	nd	nd	nd	-		"Gold was also produced, but information was inadequate to make reliable estimates of output." "...gold was also produced by artisanal miners"	nd	nd	nd	nd	nd
Benin	nd	nd	nd	nd	-		"In addition to the commodity listed.. gold...were produced, but available information is inadequate to make reliable estimates of output." "Gold was also produced in small quantities by artisanal miners."	11,497	5,909	9,978	10,502	10,766
Botswana	1,770	1,560	1,522	1,206	no		Reported as bullion; historically included silver; estimated to be about 2%	1,007	1,182	1,536	1,281	996
Burkina Faso	22,939	31,774	27,850	32,714	no	1,600- 5,000	"Does not include production from artisanal mining, which was estimated to fluctuate between 1,600 and 5,000 kilograms per year."	27,778	40,772	0	36,709	42,232
Burundi	300	300	400	400	n.i.	400	"Gold, mine output, Au content"; estimated data, rounded to no more than three significant digits.	313	1,152	2,117	2,915	672
Cabo Verde	0	0	0	0				nd	nd	nd	nd	nd
Cameroon	1,600	1,600	1,500	not published yet	yes	1,500	"Gold, mine output, Au content"; from artisanal mining.	2	4	181	0	78
Central African Republic	59	53	55	not published yet	yes	55	"Gold, mine output, Au content"; diamond and gold production; mostly artisanal	48,867	20,445	99	689,717	0
Chad	nd	nd	nd	nd			"In addition to the commodity listed.. gold...were produced, but available information is	nd	nd	nd	nd	nd

	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **					
	2010	2011	2012	2013				2010	2011	2012	2013	2014	
							inadequate to make reliable estimates of output."						
Comoros	nd	nd	nd	nd				nd	nd	nd	nd	nd	nd
Congo	150	150	150	150	yes	150	"Gold, mine output, Au content", artisanal production	nd	nd	nd	nd	nd	nd
Democratic Republic of the Congo	12,000	12,000	14,000	17,000	yes	11,000-14,000 2013: Estimated 6,000 tonnes from ASGM in Ituri region	"Gold, mine output, Au content"; Estimated; estimated data are rounded to no more than three significant digits; artisanal and small-scale miners and industrial production	nd	nd	nd	nd	nd	nd
Cote d'Ivoire	5,310	9,870	10,420	12,862	no		"Gold, mine output, Au content"; does not include production from artisanal mining.	5,419	13,114	13,120	14,157	19,136	
Djibouti	0	0	0	0				nd	nd	nd	nd	nd	nd
Equatorial Guinea	nd	nd	nd	nd			Equatorial Guinea presumably produced gold...but available information was inadequate to make reliable estimates of output	nd	nd	nd	nd	nd	nd
Eritrea	50	11,790	9,740	2,900	no			nd	nd	nd	nd	nd	nd
Ethiopia	6,770	10,890	12,310	12,580			"Gold, mine output, Au content"	5,703	3,119	4,146	-17,118	-76,059	
Gabon	nd	nd	666	1,136	no		Does not include production from artisanal mining, represents production from the Bakoudou Mine only	nd	nd	nd	nd	nd	nd
Gambia	0	0	0	0				-1,035	-2,999	-353	-830	0	
Ghana	76,330	82,920	86,700	88,376	no	>30,000	"Gold, mine output, Au content"; does not include artisanal mining output, which in 2010 and 2011 was estimated to be 25 and 30 tonnes, respectively.	96,012	117,767	224,622	139,888	0	

	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **				
	2010	2011	2012	2013				2010	2011	2012	2013	2014
Guinea	15,217	15,695	14,790	15,428	no	1,500-5,000	"Gold, mine output, Au content"; does not include artisanal gold mining production, which has historically ranged between 1,500 and 5,000 kg/year	0	0	0	5,572,119	7,536,906
Guinea-Bissau	0	0	0	0				nd	nd	nd	nd	nd
Kenya	2,365	1,636	3,600	2,100	yes	2,100-3,600	"Gold, mine output, Au content"; artisanal miners accounted for most of Kenya's gold. Decreased production could be attributable to decreased gold prices.	3,428	0	0	30,096	0
Lesotho	0	0	0	0				nd	nd	nd	nd	nd
Liberia	666	448	641	600	yes	450-670	"Gold, mine output, Au content"; from artisanal mining.	nd	nd	nd	nd	nd
Madagascar	30	40	400	nd	no	1000-2000	"Gold, mine output, Au content"; estimated data, rounded to no more than three significant digits. Does not include smuggled artisanal production, which is estimated to be from 1,000 to 2,000 kg/year.	nd	nd	nd	nd	nd
Malawi	0	0	0	0				nd	nd	nd	nd	nd
Mali	36,360	35,730	40,130	40,803		6,000	"Gold, mine output, Au content"; excludes artisanal production, which for the period 2010-2012 was estimated to be about 4,000 to 5,000 kg/year of gold. Artisanal miners were estimated to have produced more than 6,000 kg of gold during 2013	48,242	42,405	44,929	0	0
Mauretania	8,305	8,172	7,652	9,517	no			6,605	6,857	6,324	8,284	8,627
Mozambique	106	111	178	198	no	600	Does not include unreported production; total output of gold was estimated to be roughly	20	2,009	2,806	2,000	1,271

	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **				
	2010	2011	2012	2013				2010	2011	2012	2013	2014
							600 to 900 kg/year					
Mauritius and Seychelles	0	0	0	0				-1,006	-484	62	26	1,017
Namibia	2,700	2,050	2,300	1,960	no		"Gold, mine output, Au content"; excludes gold recovered as a byproduct of copper mining.	3,396	2,351	2,926	2,712	3,298
Niger	1,950	1,960	1,660	1,150	yes	267	"Gold, mine output, Au content"; includes artisanal and small-scale production of gold, which averaged 267 kg/year from 2008 to 2012	1,929	-850	0	1,132	-1
Nigeria	3,720	4,000	4,000	4,200	yes		Gold was mined primarily by small-scale artisanal operations. Since 2012, several mining companies started gold exploration as well.	nd	nd	nd	nd	nd
Reunion	0	0	0	0				-155	-606	0	0	188
Rwanda	3	3	3	0			"Gold, mine output, Au content"; reported exports	nd	nd	nd	nd	nd
Senegal	4,380	4,089	6,666	update not available	no	600	"Gold, mine output, Au content"; in 2008, the government estimated an unreported production of artisanal gold of 600 kg. Since then, no artisanal mining has been reported.	8,258	7,611	7,861	9,072	10,116
Sierra Leone	270	164	135	98	no		"Gold, mine output, Au content". Sierra Leone's mining and mineral processing operations were privately owned.	nd	nd	nd	nd	nd
Somalia	nd	nd	nd	nd			"Gold and construction materials, such as brick clay, were also produced but no output was reported"	nd	nd	nd	nd	nd
South Africa, Mine	188,702	180,293	154,178	159,724	no			-20,016	200,220	163,869	147,663	114,613

	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **				
	2010	2011	2012	2013				2010	2011	2012	2013	2014
South Africa, Refined	385,244	476,229	440,000	440,000	no			nd	nd	nd	nd	nd
South Sudan	nd	nd	nd	nd			"Artisanal miners produced gold at Nanakanak in Eastern Equatoria State"	nd	nd	nd	nd	nd
Sudan	26,317	23,739	46,133	24,813	yes		"Gold, mine output, Au content"; reported exports; Artisanal miners accounted for most of Sudan's gold production.	29,665	11,972	43,699	nd	nd
Sudan, Refined	--	--	9,000	24,000	n.i.		"Estimated data, rounded to no more than three significant digits."	nd	nd	nd	nd	nd
Swaziland	0	0	0	0				nd	nd	nd	nd	nd
Tanzania	39,448	42,300	40,650	43,390	no		Annual capacity of large scale mines is estimated at 48,900 kg/year. Artisanal mining reported in the district of Mrito only with no quantitative estimate.	318,564	41,042	568,033	239,674	279,942
Togo	10,452	16,469	16,500	19,000	partly		May include artisanal gold production from neighboring countries; however, information is inadequate to make reliable estimates of output that originated from these countries. Annual capacity of large scale mines is estimated at 16,400 kg/year.	10,583	5,280	17,908	21,330	0
Uganda, Mine	4	1	1	--	yes	1		797	215	329	84	1,939
Uganda, Refined	450	150	200	50			"Estimated data, rounded to no more than three significant digits."					
Zambia	3,600	3,800	4,500	4,500	no			555,324	1,823	1,491,872	3,758	2,809
Zimbabwe	9,100	12,824	14,742	14,065	n.i.	3,000	"Artisanal miners, including small-scale miners and syndi-	88,721	7,299	15,570	2,321,435	13,062

	Production, kg/year *				ASGM included	Estimated ASGM production, kg gold/year	Note in " " by USGC	Net export, kg/year **					
	2010	2011	2012	2013				2010	2011	2012	2013	2014	
							cates. Various locations". 3,000 kg						
Total (excl. refined)	480,973	516,431	524,172	510,870 (a few countries still not updated)		48,000-59,000		1,249,918	527,609	2,621,634	9,236,606	7,971,608	

\* Source: Minerals Yearbook, United States Geological Survey, at: <http://minerals.usgs.gov/minerals/>

\*\* Source: Comtrade database, sum of 284330, Gold compounds and 7108, Gold, unwrought, semi-manufactured, powder form

n.i. : not indicated in Minerals Yearbook

## Appendix 3: Trade data for mercury added products and mercury compounds

### Fluorescent lamps

Data has been retrieved from the UN Comtrade database for the following fluorescent lamps:

853931	Name: Fluorescent lamps, hot cathode Description: Discharge lamps, other than ultra-violet lamps :-- Fluorescent, hot cathode
853932	Name: Mercury or sodium vapor Description: Discharge lamps, other than ultra-violet lamps :-- Mercury or sodium vapor lamps; metal halide lamps
853940	- Ultra-violet or infra-red lamps, arc lamps
853941	Name: Arc-lamps Description: Ultra-violet or infra-red lamps; arc-lamps :-- Arc-lamps
853949	Name: Ultra-violet or infra-red Description: Ultra-violet or infra-red lamps; arc-lamps :-- Other

*Table 7.1 Net-import of fluorescent lamps (double end and CFL single end, code 853931)*

	Net-import of fluorescent tubes (number of items)					
	2010	2011	2012	2013	2014	Total 2010-2014
Angola	0	0	0	0	0	0
Benin	184,092	345,890	233,093	237,002	356,035	1,356,112
Botswana	1,089,156	303,236	140,964	142,890	315,892	1,992,138
Burkina Faso	370,767	291,749	0	386,331	308,765	1,357,612
Burundi	128,104	53,266	113,611	200,951	7,264	503,196
Cameroon	1,008,772	1,015,218	821,769	0	1,421,152	4,266,911
Cape Verde	89,297	147,382	68,456	65,646	88,184	458,965
Central African Rep	7,075	99,769	6,212	1,573	934	115,563
Chad	0	0	0	0	0	0
Comoros	30	237	78	0	0	345
Congo	130,749	307,542	347,852	297,255	400,058	1,483,456
Cote d'Ivoire	663,255	504,533	909,230	3,243,079	3,171,651	8,491,748
Dem Rep of the Congo	0	0	0	0	0	0
Djibouti	0	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0
Ethiopia	855,264	4,141,213	888,232	3,778,465	1,484,161	11,147,335
Gabon	0	0	0	0	0	0
Gambia	60,450	1,312	647	12	440	62,861
Ghana	6,571,814	11,523,072	13,431,886	11,489,470	0	43,016,242
Guinea	0	0	0	58,437	65,612	124,049
Guinea-Bissau	0	0	0	0	0	0

	Net-import of fluorescent tubes (number of items)					
	2010	2011	2012	2013	2014	Total 2010-2014
Kenya	5,222,681	0	0	7,785,200	0	13,007,881
Lesotho	-119,681	-3,372,159	-9,841,222	0	0	-13,333,062
Liberia	0	0	0	0	0	0
Madagascar	127,006	144,196	0	665,033	186,203	1,122,438
Malawi	115,222	135,908	120,613	163,344	115,794	650,881
Mali	599,372	65,567	66,395	0	0	731,334
Mauritania	32,300	50,877	7,061	10,649	11,064	111,951
Mauritius	1,208,288	971,766	1,163,191	1,169,654	830,679	5,343,578
Mayotte	0	0	0	0	0	0
Mozambique	211,809	388,892	1,292,326	648,617	467,468	3,009,112
Namibia	-1,126	88,140	31,838	45,267	71,304	235,423
Niger	124,686	62,718	185,666	205,617	194,559	773,246
Nigeria	4,532,277	6,943,032	3,354,347	2,087,073	1,559,710	18,476,439
Réunion	0	0	0	0	0	0
Rwanda	55,673	546,708	9,242	20	6,110	617,753
Sao Tome & Principe	2,678	14,788	3,360	16,551	12,687	50,064
Senegal	427,165	293,521	325,497	555,884	461,885	2,063,952
Seychelles	0	0	0	0	0	0
Sierra Leone	0	0	0	0	607,238	607,238
Somalia	0	0	0	0	0	0
South Africa	36,565,764	32,537,490	29,051,851	25,241,763	37,081,989	160,478,857
South Sudan	0	0	0	0	0	0
Sudan	4,699	3,223	848	0	0	8,770
Swaziland	0	0	0	0	0	0
Togo	22,334	90,943	98,091	75,878	0	287,246
Uganda	483,254	699,761	4,088,456	2,615,408	3,380,730	11,267,609
U. Rep of Tanzania	1,043,274	428,897	488,713	589,946	1,054,436	3,605,266
Zambia	683,623	1,240,346	330,278	370,858	610,339	3,235,444
Zimbabwe	236,204	128,055	511,940	70,552	8,642	955,393
Total	62,736,327	60,197,088	48,250,521	62,218,425	54,280,985	287,683,346

Table 7.2 Net-import of Mercury or sodium vapor lamps; metal halide lamps (code 853932) (number of items)

	Net-import of mercury or sodium vapor lamps; metal halide lamps (number of items)					
	2010	2011	2012	2013	2014	Total 2010-2014
Angola	0	0	0	0	0	0
Benin	3,548	0	76	163	0	3,787



	Net-import of mercury or sodium vapor lamps; metal halide lamps (number of items)					
	2010	2011	2012	2013	2014	Total 2010-2014
Botswana	7,037	21,059	7,157	7,971	21,439	64,663
Burkina Faso	13,713	12,602	0	7,635	30,915	64,865
Burundi	90	324	933	0	2	1,349
Cameroon	5,939	10,788	9,942	0	11,126	37,795
Cape Verde	2,556	5,405	664	2,623	3,844	15,092
Central African Rep	446	0	242	0	789	1,477
Chad	0	0	0	0	0	0
Comoros	0	0	0	20	0	20
Congo	3,779	2,034	3,734	4,943	10,359	24,849
Cote d'Ivoire	4,709	8,474	27,107	34,797	102,530	177,617
Dem Rep of the Congo	0	0	0	0	0	0
Djibouti	0	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0
Ethiopia	25,425	10,654	25,610	33,387	45,758	140,834
Gabon	0	0	0	0	0	0
Gambia	0	0	0	0	0	0
Ghana	14,856	29,451	15,247	11,774	0	71,328
Guinea	0	0	0	6	1,316	1,322
Guinea-Bissau	0	0	0	0	0	0
Kenya	36,153	0	0	30,731	0	66,884
Lesotho	262	-1,887	2,373	0	0	748
Liberia	0	0	0	0	0	0
Madagascar	14,000	2,772	0	1,339	1,626	19,737
Malawi	11,910	4,988	6,295	8,307	21,155	52,655
Mali	7,429	1,782	5,646	0	0	14,857
Mauritania	3,011	0	1,569	516	2,269	7,365
Mauritius	15,578	14,828	18,772	10,414	11,120	70,712
Mayotte	0	0	0	0	0	0
Mozambique	4,770	22,688	22,982	75,221	8,203	133,864
Namibia	2,421	1,694	7,787	1,861	5,110	18,873
Niger	946	1,217	472	190	2,762	5,587
Nigeria	523,030	102,779	21,423	40,692	50,590	738,514
Réunion	0	0	0	0	0	0
Rwanda	1,992	220	341	836	106	3,495
Sao Tome & Principe	77	95	12	34	523	741
Senegal	7,904	6,057	2,487	1,211	63,681	81,340

	Net-import of mercury or sodium vapor lamps; metal halide lamps (number of items)					
	2010	2011	2012	2013	2014	Total 2010-2014
Seychelles	0	0	0	0	0	0
Sierra Leone	0	0	0	0	51,347	51,347
Somalia	0	0	0	0	0	0
South Africa	5,793,947	1,770,161	904,961	1,057,374	3,125,630	12,652,073
South Sudan	0	0	0	0	0	0
Sudan	2	0	0	0	0	2
Swaziland	0	0	0	0	0	0
Togo	3,395	4,662	306	1,787	0	10,150
Uganda	1,817	1,315	4,429	5,165	56,457	69,183
U. Rep of Tanzania	7,697	2,797	6,180	14,020	15,013	45,707
Zambia	5,088	13,064	10,009	6,371	9,400	43,932
Zimbabwe	7,652	56,159	26,024	8,932	17,523	116,290
Total	6,531,179	2,106,182	1,132,780	1,368,320	3,670,593	14,809,054

### Mercury oxides batteries

Data have been extracted the UN Comtrade database for the following CN codes:

8506 30 10	Mercuric oxide cells and batteries, in the form of cylindrical cells (excl. spent)
8506 30 30	Mercuric oxide cells and batteries, in the form of button cells (excl. spent)
8506 30 90	Mercuric oxide cells and batteries (excl. spent, and in the form of cylindrical or button cells)

Table 7.3 Net import of mercury oxide batteries (Code 850630)

	Net-import of mercury oxide batteries, t/year					
	2010	2011	2012	2013	2014	Total 2010-2014
Angola	nd	nd	nd	nd	nd	nd
Benin	0	0	0	324	0	324
Botswana	5	5	3	8	19	41
Burkina Faso	0	0	0	0	0	0
Burundi	1	516	68	6	0	591
Cameroon	78	-1	27	36	0	140
Cape Verde	0	0	0	0	0	0
Central African Rep	0	0	0	0	0	0
Chad	0	0	27	0	0	27
Comoros	34	13	8	13	0	68
Congo	5	3	39	24	59	129
Cote d'Ivoire	4	3	2,109	512	120	2,748
Dem Rep of the Congo	0	0	0	0	0	0

	Net-import of mercury oxide batteries, t/year					
	2010	2011	2012	2013	2014	Total 2010-2014
Djibouti	0	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0
Ethiopia	1,342	183	0	181	455	2,161
Gabon	0	0	0	0	0	0
Gambia	4,209	6,608	4,610	4,876	2,888	23,191
Ghana	1	1	38	4	0	45
Guinea	0	0	0	0	0	0
Guinea-Bissau	0	0	0	0	0	0
Kenya	0	0	0	0	0	0
Lesotho	0	0	0	0	0	0
Liberia	0	0	0	0	0	0
Madagascar	5	0	0	4	0	10
Malawi	11	18	0	1	2	33
Mali	0	0	0	0	0	0
Mauritania	48	197	193	102	624	1,164
Mauritius	0	0	0	0	9	9
Mayotte	0	0	0	0	0	0
Mozambique	0	0	28	139	167	334
Namibia	126	127	12	0	-26	239
Niger	0	0	0	0	0	0
Nigeria	0	0	14	37	78	130
Réunion	0	0	0	0	0	0
Rwanda	26	1	0	0	3	30
Sao Tome & Principe	0	0	0	0	0	0
Senegal	0	0	0	0	0	0
Seychelles	0	0	0	0	0	0
Sierra Leone	0	0	0	0	0	0
Somalia	0	0	0	0	0	0
South Africa	0	0	0	0	26	26
South Sudan	0	0	0	0	0	0
Sudan	36	0	2	0	0	37
Swaziland	0	0	0	0	0	0
Togo	0	0	0	1	0	1
Uganda	4	0	-23	4	5	-11
U. Rep of Tanzania	20	22	22	67	10	141
Zambia	3	32	5	37	4	80

	Net-import of mercury oxide batteries, t/year					
	2010	2011	2012	2013	2014	Total 2010-2014
Zimbabwe	4	0	0	0	1	5
Total	5,962	7,730	7,180	6,376	4,444	31,692

## Mercury compounds

Data have been retrieved from the Comtrade databased for inorganic and organic compounds of mercury:

2852 00 Compounds, inorganic or organic, of mercury (excl. amalgams)

Table 7.4 Net-import of mercury compounds (Code 2852 00)

	Net-import of mercury compounds, kg/y					
	2010	2011	2012	2013	2014	Total 2010-2014
Angola	nd	nd	nd	nd	nd	nd
Benin	nd	nd	nd	nd	nd	nd
Botswana	nd	nd	nd	nd	nd	nd
Burkina Faso	nd	1	nd	8	89	98
Burundi	nd	nd	nd	10	nd	10
Cameroon	nd	nd	nd	nd	nd	nd
Cape Verde	nd	nd	85	nd	nd	85
Central African Rep	nd	nd	nd	nd	nd	nd
Chad	nd	nd	nd	nd	nd	nd
Comoros	nd	nd	nd	nd	nd	nd
Congo	nd	nd	nd	nd	nd	nd
Cote d'Ivoire	85	140	184	225	6,433	7,067
Dem Rep of the Congo	nd	nd	nd	nd	nd	nd
Djibouti	nd	nd	nd	nd	nd	nd
Equatorial Guinea	nd	nd	nd	nd	nd	nd
Eritrea	nd	nd	nd	nd	nd	nd
Ethiopia	3	nd	7	30,592	nd	30,602
Gabon	nd	nd	nd	nd	nd	nd
Gambia	nd	nd	nd	nd	415,562	415,562
Ghana	-4,728	127	148	nd	nd	-4,453
Guinea	nd	nd	nd	nd	nd	nd
Guinea-Bissau	nd	nd	nd	nd	nd	nd
Kenya	12	nd	nd	149	nd	161
Lesotho	nd	nd	nd	nd	nd	nd
Liberia	nd	nd	nd	nd	nd	nd
Madagascar	6	2	nd	nd	nd	8
Malawi	113	nd	4	390	nd	507

	Net-import of mercury compounds, kg/y					
	2010	2011	2012	2013	2014	Total 2010-2014
Mali	nd	1,016	nd	nd	nd	1,016
Mauritania	nd	nd	nd	nd	nd	nd
Mauritius	153	21	nd	nd	nd	174
Mayotte	nd	nd	nd	nd	nd	nd
Mozambique	nd	nd	nd	14	351	365
Namibia	-402	835	nd	nd	nd	433
Niger	54	20	1,573	1,884	nd	3,531
Nigeria	nd	nd	nd	nd	nd	nd
Réunion	nd	nd	nd	nd	nd	nd
Rwanda	383	11,897	165	nd	nd	12,445
Sao Tome & Principe	nd	nd	nd	nd	nd	nd
Senegal	5,124	1,753	165	6,457	161	13,660
Seychelles	nd	nd	nd	nd	nd	nd
Sierra Leone	nd	nd	nd	nd	6	6
Somalia	nd	nd	nd	nd	nd	nd
South Africa	-157,611	-359,266	nd	nd	nd	-516,877
South Sudan	nd	nd	nd	nd	nd	nd
Sudan	409,632	41	nd	nd	nd	409,673
Swaziland	nd	nd	nd	nd	nd	nd
Togo	nd	nd	nd	nd	nd	nd
Uganda	5	513	nd	nd	nd	518
U. Rep of Tanzania	1,192	135	15,926	nd	nd	17,253
Zambia	260	1,049	nd	nd	nd	1,309
Zimbabwe	9,992	3,375	1	nd	nd	13,368
Total	264,273	-338,341	18,258	39,729	422,602	406,521

## Appendix 4: Import of amalgams

Net import of amalgams of precious metals (Code 28 43 90) and estimated consumption of mercury in dental amalgams are shown in the table below. An export of about 45 tonnes per year from Germany to South Africa is reported by each of the countries. Export of amalgam from South Africa to Zimbabwe is registered by both countries. The large registered import to Ethiopia and Mauritania is not confirmed by data from the exporting country.

	Net-import of amalgams of precious metals, kg/y						Estimated consumption of mercury in dental amalgams* kg/y
	2010	2011	2012	2013	2014	Total 2010-2014	
Angola	nd	nd	nd	nd	nd	nd	43
Benin	nd	nd	nd	nd	nd	nd	36
Botswana	-3,985	656	578	28	1	-2,722	9
Burkina Faso	nd	nd	nd	60	nd	60	64
Burundi	nd	nd	nd	nd	nd	nd	58
Cameroon	nd	nd	nd	nd	-1,750	-1,750	139
Cape Verde	256	1	nd	2	0	259	3
Central African Rep	nd	nd	nd	nd	nd	nd	13
Chad	nd	nd	nd	nd	nd	nd	34
Comoros	nd	nd	nd	nd	nd	nd	5
Congo	nd	5	nd	nd	nd	5	15
Cote d'Ivoire	113	nd	nd	1	305	419	101
Dem Rep of the Congo	nd	nd	nd	nd	nd	nd	150
Djibouti	nd	nd	nd	nd	nd	nd	3
Equatorial Guinea	nd	nd	nd	nd	nd	nd	7
Eritrea	nd	nd	nd	nd	nd	nd	13
Ethiopia	15,001	3	14	70,137	20,957	106,112	301
Gabon	nd	nd	nd	nd	nd	nd	15
Gambia	nd	nd	nd	nd	nd	nd	10
Ghana	1,047	8	69	235	nd	1,359	107
Guinea	nd	nd	nd	nd	nd	nd	43
Guinea-Bissau	nd	nd	nd	nd	nd	nd	6
Kenya	56	nd	nd	110	nd	166	403
Lesotho	0	nd	nd	nd	nd	nd	8
Liberia	nd	nd	nd	nd	nd	nd	14
Madagascar	1	105	6	121	3	236	111
Malawi	nd	nd	nd	nd	nd	nd	59
Mali	49	489	nd	nd	nd	538	59

	Net-import of amalgams of precious metals, kg/y						Estimated consumption of mercury in dental amalgams*
	2010	2011	2012	2013	2014	Total 2010-2014	kg/y
Mauritania	nd	nd	nd	nd	111,790	111,790	17
Mauritius	64	130	82	73	158	507	58
Mayotte	nd	nd	nd	nd	nd	nd	-
Mozambique	0	100	251	20	nd	371	89
Namibia	155	133	10	184	24	506	29
Niger	nd	nd	126	101	nd	227	62
Nigeria	nd	nd	nd	789	nd	789	646
Réunion	nd	nd	nd	nd	nd	nd	-
Rwanda	1,150	822	270	24	58	2,324	42
Sao Tome & Principe	nd	nd	nd	nd	nd	nd	3
Senegal	nd	nd	nd	nd	nd	nd	51
Seychelles	nd	nd	nd	nd	nd	nd	25
Sierra Leone	nd	nd	nd	nd	nd	nd	23
Somalia	nd	nd	nd	nd	nd	nd	28
South Africa	27,918	24,384	8,036	15,711	45,650	121,699	1,600
South Sudan	nd	nd	nd	nd	nd	nd	-
Sudan	nd	1,220	3,658	nd	nd	4,878	290
Swaziland	nd	nd	nd	nd	nd	nd	8
Togo	nd	nd	nd	nd	nd	nd	25
Uganda	1,701	1,002	nd	nd	392	3,095	125
U. Rep of Tanzania	57	518	nd	958	14	1,547	171
Zambia	286	3,019	3,421	2,369	-90	9,005	141
Zimbabwe	285	488	1,954	830	2,511	6,068	71
<b>Total</b>	<b>44,154</b>	<b>33,083</b>	<b>18,475</b>	<b>91,753</b>	<b>180,023</b>	<b>367,488</b>	<b>5,333</b>

\* Represents the mercury content of dental amalgam used in the country. The UNEP Mercury Toolkit (Version April 2015) applies population data for 2010 and WHO data for density of dental personnel from 1997 to 2004 (varies by country).

## Appendix 5 Mercury trade data for other selected countries

Detailed import and export data for the participating countries are included in the separate report with country baseline data.

### Republic of South Africa

Table 7.5 Import of mercury (28 05 40) 2010-2014 in kg to South Africa by country\*

	2010	2011	2012	2013	2014	2015
Belgium		1,725				
China	53	634				
China Hong Kong SAR				2,588		
Germany	31	334	20,000	6		
Guatemala					1,725	
India					24	74
Japan						6,900
Mexico						6,900
Netherlands	2,550	1,799	3,450			
Singapore			3,450	5,583	8,889	5,175
South Africa				1,966		
Switzerland	1			1		21,565
Ukraine					1,725	
United Arab Emirates						2,308
United Kingdom	2,946	34	4,396		2,864	
USA	1	3,453	9,983	22,146	12,862	8,625
Total	5,582	7,979	41,279	32,290	28,089	51,547

\* Source: Comtrade database

Table 7.6 Export of mercury (28 05 40) 2010-2014 in kg to South Africa by country

	2010	2011	2012	2013	2014	2015
Australia				1,948		
Botswana	15					
China Hong Kong SAR		8,592	12,076	7,677	10,818	1,725
Germany	291	9				
Guatemala					1,906	
India					190	97



	2010	2011	2012	2013	2014	2015
Mexico						5,174
Namibia					152	
Netherlands	6,971	60				
Singapore		863	23,474	18,362	11,730	21,735
Switzerland	2					3
United Kingdom	900					
USA			150	90		
	8,179	9,524	35,700	28,077	24,796	28,734

\* Source: Comtrade database

Table 7.7 Export of mercury (28 05 40) 2010-2014 in kg from South Africa by country

	2010	2011	2012	2013	2014	2015
Botswana	5	68	36	60	61	26
Dem. Rep. of the Congo	10	41	1	120	11	
Mali	1					
Mozambique	6	51	10		60	
Namibia	3	38	188	350	0	154
Rwanda	3					
Zimbabwe	2	240	1,082	1,688	1,359	
Swaziland	150	20		2	1	2
Uganda		20				
Nigeria		1				
Tanzania		5	126		11	
Zambia			50	17		90
Angola				57		
Mauretania				1		
Turkey				23		
Total	180	484	1,493	2,318	1,503	272

\* Source: Comtrade database

## Ethiopia

Table 7.8 Import of mercury Code 28 05 40) 2010-2014 in kg to Ethiopia by country\*

	2010	2011	2012	2013	2014	2015
Area, nes	nd	nd	nd	171,303	218,428	nd
India	nd	nd	nd	31	nd	nd

China	631	nd	nd	nd	nd	10
United Arab Emirates	209	nd	nd	nd	nd	nd
Germany	nd	2	nd	nd	nd	nd
Italy	nd	2	nd	nd	nd	7
Czech Rep.	nd	nd	2	nd	nd	nd
Switzerland	nd	nd	2	nd	nd	nd
USA	nd	nd	3	nd	nd	nd
Total	840	4	7	171,335	218,428	17

\* Source: Comtrade database

Table 7.9 Export of mercury Code 28 05 40) 2010-2014 to Ethiopia as reported by partner country\*

	2010	2011	2012	2013	2014	2015
India	nd	nd	nd	nd	5	nd
Total	0	0	0	0	5	0

\* Source: Comtrade database

No export of mercury from Ethiopia was recorded.

## Togo

Table 7.10 Import of mercury Code 28 05 40) 2010-2014 in kg to Togo by country\*

	2010	2011	2012	2013	2014	2015
Belgium	4,575	2,374				
China	1,738		9,576	20,457	30,045	31,133
China Hong Kong SAR		790	12,474	1,540		
France	2,929					
Germany		1,725				
Ghana		600				
India					3,450	6,210
Italy					1,725	
Japan	1,725					
Kyrgyzstan	2,588					
Lebanon		2,587				
Netherlands	3,451		422			
Netherlands		1,725				
Panama		5,200				
Singapore						197
South Africa		2,588				
Spain	1,725	2,820				
Turkey					5,762	6,210
Ukraine			2,587			
USA		1,725	1,621			
Total	18,737	19,809	29,005	21,997	40,982	43,750

\* Source: Comtrade database

Table 7.11 Export of mercury Code 28 05 40) 2010-2014 to Togo as reported by partner country

	2010	2011	2012	2013	2014	2015
Belgium	3,793	552				
China, Hong Kong SAR		2,588	14,375	14,032	25,149	
Germany	8,000					
Netherlands	10,365	1,725				
Panama		16,187				
Singapore		1,725	3,450	6,900		16,388
Spain	3,278	2,243				
Total	25,436	25,020	17,825	20,932	25,149	16,388

*Table 7.12 Export of mercury (28 05 40) 2010-2014 in kg from Togo by country*

	2010	2011	2012	2013	2014
Burkina Faso		6,038			

## Appendix 6: List of miners' organizations

As part of the project on development of mercury trade diagnostics, contact was established with the following associations of miners in the participating countries.

Country	Name of association	Contact persons	Role	Contact details
Zimbabwe	Zimbabwe Miners Federation (ZMF) 1	Mr Dosman Mangisi	Public Relations and Mining Promotions	0772942473
		Mr Wellington Takavarasha	Chief Executive Officer	<a href="mailto:welly.takavarasha@yahoo.com">welly.takavarasha@yahoo.com</a> 0772986436
	Zimbabwe Gold Miners Association	Eng. Davison Svuuire	National Technical Advisor	<a href="mailto:dsvuuire@gmail.com">dsvuuire@gmail.com</a> +263773616146; +263734146066
Uganda	Uganda National Artisanal and Small-Scale Miners Association	Sasirwe Jonny	Chairperson	<a href="mailto:shaft_sinkers@yahoo.com">shaft_sinkers@yahoo.com</a> +256772416028; +2567014116028
Ghana	Ghana National Association of Small Scale Miners	Alhaji Baba Ahmed	National Organizer	<a href="mailto:Albamed505@yahoo.com">Albamed505@yahoo.com</a> 0209-878277; 0244-935589; 0277-951730
		Emmanuel Dzeble	National Administrator	<a href="mailto:emmanueldzeble@yahoo.com">emmanueldzeble@yahoo.com</a> 0204-966144; 0235966144
DR Congo	PROMINES (ASM organisation).	Mabolia Yenga.	National Coordinator	<a href="mailto:ymabolia@prominesrdc.cd">ymabolia@prominesrdc.cd</a> ; +243974325001
Côte d'Ivoire	Artisanal Miners Union (UNOMICI)	Mrs. Fadiga Sirakoné	President	+225 07 67 91 31 <a href="mailto:unomici@yahoo.fr">unomici@yahoo.fr</a>
	Societe Coopérative Minière de Côte d'Ivoire (SCOOPS-COOMICI)	Mr. Bamba Zakary	President	+225 49 98 17 42 <a href="mailto:info@coomici.org">info@coomici.org</a>
Tanzania	Tanzania Women Miner's Association	Ms Eunice Peter Negele	Chairperson	+255-744-271-649 / +255-745-877-644
	Mwanza Regional Miners Association (MWAREMA)	Mr Richard Sen	Secretary General	+255-762-401-324
	Geita Regional Miners Association (GEREMA)	Mr Christopher Kadeo	Chairperson	+255-754-304-739
		Mr Golden Njombo Hainga	Secretary	0712764827
	Federation of Miners Associations of Tanzania (FEMATA)	Mr John Bina	President	+255 755-550707
	Mr Golden Njombo Hainga	General Secretary	0712764827	
	Geita Women Miners Association (GWOMA)	Ms Teresia Samwel	Chairperson	+255 755 462 542
Senegal	Federation des Orpailleurs de la Région de Kédougou - FORK	Mr Mamadou Drame	President	+221 774184072 +221 770114332
Burkina Faso	Le Syndicat national des orpailleurs artisanaux et traditionnels du Burkina	Mr Valentin Koaman	Secrétaire général	Mobile : +226 78996299 Adresse mail : <a href="mailto:soulimw14@yahoo.fr">soulimw14@yahoo.fr</a> Autre adresse mail : <a href="mailto:valentinkoama@gmail.com">valentinkoama@gmail.com</a>
	Association des orpailleurs	Cyril Sawadogo	Founder	Mobile : +226 70248298 Adresse mail : <a href="mailto:orpailleursbf@gmail.com">orpailleursbf@gmail.com</a> Autre adresse mail : <a href="mailto:sacyillose6@yahoo.fr">sacyillose6@yahoo.fr</a>

## Appendix 7: Questionnaire sent to the countries

The following questionnaire was sent to the countries in English and French, respectively.

### Introduction [included in e-mail]

The World Bank has launched a project "Development of Mercury Trade Diagnostic for Sub-Saharan Africa". The project is implemented for the World Bank by COWI A/S, Denmark, with COWI Tanzania and groundWork, Republic of South Africa, as sub-consultants. Please find an introduction letter from the World Bank attached.

The objectives of the project is to:

1. Improve the understanding of mercury trade in Sub-Saharan Africa; in particular, the trade related to the informal artisanal and small scale gold mining (ASGM) sector.
2. Build a sub-regional understanding of the trade and use of mercury in Sub-Saharan Africa.

As part of the project, investigations of mercury use in ASGM and mercury trade are carried out in eight participating countries: Tanzania, Uganda, Zimbabwe, DR Congo, Ghana, Senegal, Côte d'Ivoire and Burkina Faso.

In order to extend the assessment of the mercury trade to the entire Sub-Saharan Africa, this questionnaire to other countries in the region has been prepared.

A preliminary assessment of mercury trade and use in ASGM in Sub-Saharan Africa is attached to this questionnaire in order to provide a first overview on the basis of the existing information. The aim is to later update the assessment on the basis of the data collected through this questionnaire and other activities within the project.

We are aware that detailed national studies of mercury use in ASGM is underway as part of the preparation of the national action plans (NAP) for ASGM in most of the countries contacted. However, we hereby kindly ask if preliminary information on specific issues could be provided in order to improve the understanding on mercury trade and use in Sub-Saharan Africa.

If you have any questions or comments to this request, please do not hesitate to contact us using the contact details below.

We are looking forward to your answer.

Yours sincerely,

Carsten Lassen,  
Project Manager

Name of country	
Name of institution	
Name of contact person	
Email of contact person	

Phone number of contact person			
Date and year			
Production of mercury (Hg)			
Is mercury produced in the country or placed on the market from any of the sources indicated below ?			
Source	Is the source present	If YES, at what approximate quantities ? (tonnes mercury marketed/year)	Remark on source
Primary mercury mining	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
By-product mercury production (from nonferrous metal production, natural gas or other sources)	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Mercury from chlor-alkali plants	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Mercury from other industrial applications of mercury	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Recovery of mercury from waste (industrial and non-industrial)	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Reclamation of contaminated sites including tailings from artisanal and small scale mining	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
National stocks of mercury	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Use of liquid mercury (apart from ASGM)			
Is liquid mercury used in the country for any of the applications indicated below ?			
Application	Is liquid mercury used?	If YES, at what approximate quantities used? (tonnes Hg/year)	Remark on application
Production of chlor alkali	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
P in the chemical industry	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Production of mercury added products with liquid mercury (for example measuring equipment)	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Dental amalgam fillings	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Other direct used of liquid mercury apart from laboratory use (for example in in traditional medicine)	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Production of mercury chemicals	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
Other, please specify	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		

	<input type="checkbox"/>		
Mercury use in artisanal and small scale gold mining (ASGM)			
		If YES, at what approximate quantities ?	Remark:
Is gold produced by ASGM in the country?	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	(tonnes gold/year):	
Is mercury used in ASGM in the country?	Yes No ? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	(tonnes Hg/year):	
Approximate percentage of gold from ASGM produced with the use of mercury	Percentage: %		
Number of miners involved in ASGM in the country	Approximate range:		
Number of miners involved in mercury-based ASGM in the country	Approximate range:		
References to further information on mercury use for ASGM in the country (reports, Internet resources, or other):			
Regulation of mercury trade and use in ASGM			
Trade of mercury	<input type="checkbox"/> Mercury trade is not restricted and the companies involved do not need a license <input type="checkbox"/> Mercury trade is not restricted, but the companies involved need a specific license <input type="checkbox"/> Mercury trade is restricted to mercury for specific uses, and the companies involved need a specific license		
Mercury use in ASGM	<input type="checkbox"/> Mercury use in ASGM is prohibited <input type="checkbox"/> Mercury use in ASGM is not prohibited <input type="checkbox"/> Mercury use in ASGM is not prohibited, but the miners need a specific license to use mercury		