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Social Solutions

Reducing the Use and Release of Mercury by Artisanal and Small-Scale Gold Miners in Suriname

Review of the Suriname ASGM sector.

ARTISANAL GOLD COUNCIL

Reducing the Use and Release of Mercury by Artisanal and Small-Scale Gold Miners in Suriname: Review of the Suriname ASGM sector

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ABBREVIATIONS

ABS	General Bureau of Statistics (*Algemeen Bureau voor de Statistiek*)
ADEK	Anton de Kom (University of Suriname)
AGC	Artisanal Gold Council
ASGM	Artisanal and Small-Scale Gold Miners/Mining
ATV	All Terrain Vehicle
BO	Resort Supervisor (*Bestuursopzichter*)
BOG	Bureau Public Health care (*Bureau Openbare Gezondheidszorg*)
CI	Conservation International
CBvS	Central Bank of Suriname (*Centrale Bank van Suriname*)
CDC	Centre for Disease Control (US)
CL	Central Lab
DC	Districts Commissioner (*Districtscommissaris*)
ECD	Economic Control Service (*Economische Controle Dienst*)
EU	European Union
G.B.	Legal code
GDP	Gross Domestic Product
GMD	Geology and Mining Department (*Geologisch Mijnbouwkundige Dienst*)
GNI	Gross National Income
GoS	Government of Suriname
Grassalco	N.V. Grasshopper Aluminum Company
HDI	Human Development Index
Hg	Mercury (Chemical annotation)
IMF	International Monetary Fund
IUD	Import, Export and Currency Control (*Invoer, Uitvoer en Deviezencontrole*)
Kg	Kilograms
Km^2	Square Kilometre (*Vierkante 2ilometre*)
LBMA	London Bullion Market Association
LSGM	Large Scale Gold Mining
Mln	Million (*Miljoen*)
MOT	Meldpunt Ongebruikelijke Transacties
MSC	Mining Service Centre
NATIN	Natuur Technisch Instituut
NGO	Non Governmental Organisation
NIOSH	National Institute for Occupational Safety and Health
N.V.	Limited Liability Company (*Naamloos Vennootschap*)
NIMOS	National Institute for Environment and Development in Suriname *(Nationaal Instituut voor Milieu en Ontwikkeling in Suriname*)
NH	Natural resources (Natuurlijke Hulpbronnen), Ministry of
OGS	Regulation of the Gold Sector (*Ordening Goudsector*)
Por.	Portuguese
RGM	Rosebel Gold Mine
S.B.	State decree (*Staatsbesluit*)
SEMIF	Suriname Environmental and Mining Foundation
SGMR	Foundation Mining Title Holders (*Stichting Houders Mijnbouw Rechten*)

SGMT	School of Geology and Mining Technology
SRD	Suriname Dollar (*Surinaamse Dollar*)
Sur.	Suriname language (Sranantongo)
SMMP	School of Mining and Mineral Processing
ASGM	Small-scale gold miners
SUR	Suriname
SURGOLD	Suriname Gold Company, LLC
UNASAT	University of Applied Science and Technology
UNDP	United Nations Development Program
US	United States
USDoS	United States Department of State
USD	Unites States dollar
USGS	U.S. Geological Survey
WWF	World Wide Fund for Nature

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We also express our gratitude to stakeholders in Paramaribo who helped us obtain a better understanding of the ASGM context in Suriname. A list of consulted stakeholders is provided in Table 2.

This study was commissioned by the Artisanal Gold Council (AGC), as part of a fact finding mission in Suriname to assess the possibilities of implementing a mercury-free mining project in this country. The US Department of State provided the financial support to make this mission possible.

Opinions expressed in this report are those of the authors and do not necessarily reflect the views of the AGC, the USDoS or other institutions the authors are affiliated with. The consultant is responsible for all errors in translation and interpretation.

SUMMARY

This report describes the artisanal and small-scale gold mining (ASGM) sector in Suriname. Its aim is to assess the viability of, and develop plans for, future technical interventions focused on mercury reduction on active ASGM sites. Literature review, stakeholder consultations and field visits were used to collect information.

Suriname has a long history of ASGM, but the current rush for gold is unprecedented in terms of the number of people involved, the amount of gold produced, and the socioeconomic and environmental impacts on Suriname. Different sources estimate that the ASGM population counts between 10 and 15 thousand individuals, including mining service providers. About two-thirds to three-quarters of ASGM are foreign gold miners, mostly Brazilian garimpeiros. ASGM primarily takes place in the Greenstone belt region, in Central-East Suriname, where miners target loosely consolidated alluvial/eluvial gold bearing sediments. Virtually all locations where ASGM work are either part of a formal concession –either titled to a multinational company or to a Suriname firm or individual- or part of a traditional Indigenous or Maroon land claim. Both formal and customary land title holders ask ASGMs who work on their land for a fee, usually 10% of earnings.

An assessment of processing methods and styles shows that almost all ASGM activities in Suriname rely on gravity concentration and mercury amalgamation of sediments. The most common ASGM processing methods involve sluicing (with or without excavator), some with the addition of crushing, using hammer mills, to further increase gold liberation and recovery. Small adjustments and additions to the existing processing plants for improved process control and concentration could dramatically reduce the use of mercury. Two common pieces of equipment that may present Hg-free processing alternatives to existing practices are shaker tables (~USD 2,000- 25,000) and centrifuges (~ 19,000-35,000), followed by direct smelting of high grade concentrates. In addition to improved processing, there is a need for improved of mine planning, including prospecting.

Gradually phasing out mercury from the ASGM sector is a national policy priority. However, there are no concrete plans or strategies on how to achieve this goal. ASGMs typically sell their gold to one of the licensed gold buying houses. After purification, testing and weighing, the buying house pays the gold miner the actual spot price, compensated for the purity, minus 6 - 7%. It is likely that a share of the reported 18.9 tons of gold produced by ASGM in 2015, entered Suriname clandestinely from French Guiana and Guyana. Mercury enters Suriname clandestinely, among others from Guyana.

Many stakeholders directly or indirectly affect development of the ASGM sector. On the governmental level, the most important players are the Ministry of Natural resources, the Geology and Mining Department, the Commission Regulation of the Gold Sector, and the Central Bank of Suriname. Mining title holders in Suriname include two international Mining firms (Surgold, RGM), state mining company Grassalco, private Suriname residents, and customary rights holders. Even though Maroons and Brazilians constitute the dominant ASGM work force, they are underrepresented among the legal concession title holders. To gain and maintain a small-scale mining title the concession holder has to comply with a

number of administrative, financial, and other obligations, depending on the kind of concession. In practice, however, neither the government nor the concession holders strictly comply with the legal rules.

The main legislation governing the exploration and exploitation of mineral resources is the 1986 Mining Decree. This Mining Decree is outdated and does not specify any regulations with regard to environmental and human health. The Suriname legal framework contains no regulations about the sale of mercury.

This report presents various inventory methods that may be used to estimate and cross-check ASGM population estimates, gold production, the Hg:Au ratio, and total mercury use estimates. Based on various data sources, stakeholder interviews and field visits, various inventory estimates were established:

- Existing inventory data; the CBvS reports that in 2015, **18.9 T of ASGM gold** were exported.
- Throughput per system; estimated average of **200 T/24h processed material** per system, based on mining firm data and field measurements.
- Ore grade; **0.1-0.5 g/T recoverable gold**, based on data from the State mining firm Grassalco and a well-documented ASGM operation
- Karatage; **89-98%,** as reported by gold buying houses
- Miners per system; **5.5 workers per shift** or **11 workers per 24h operating system**, estimated by averaging the numbers of workers in different operations
- Miner earnings; average of **20-30 g Au/month**, based on interviews with ASGMs
- Hg:Au ratio; **3.34:1,** based on interviews with ASGM

The researchers imply that there may be a large degree of error in these estimates, but they provide an initial idea of the range of possibilities for the various inventory estimates of interest. The methodological descriptions will allow other researchers to cross-check the data. Future inventory estimates are advised to use a combination of different methods, using processing equipment, excavators, fuel consumption, concession holder information and export data to obtain informed estimates of relevant variables. While the proposed inventory methods are useful, the authors note that development and application of other inventory techniques may also provide valuable information.

The researchers assert that the annual minimum amount of mercury lost by ASGM operations in Suriname is 18.85 T Hg/yr based on national ASGM gold production estimates and an Hg:Au ratio of 1:1. This figure is not realistic because it assumes that no mercury is lost during the amalgamation process, and that the only mercury loss is associated with the burning of amalgam. Using the gold production estimate of 18.85 T/yr and the Hg:Au ratio of 3.34:1 derived from miner interviews and observations, suggests annual mercury emissions of 63.0 T Hg/yr.

The researchers conclude that different factors determine the feasibility of future interventions by the AGC or other groups aimed at promoting Hg-free mining, and the content and structure of these interventions. On the positive side, Suriname has national policy priorities that favor Hg-free mining. Furthermore, Suriname ASGMs have many years of experience working with highly mechanized systems, which may facilitate adoption of new concentration mechanisms. Gold miners also have proven to be willing to invest several tens of thousands of dollars in equipment – *if they are convinced that it will*

increase their profits. Furthermore, there are partners in Suriname and abroad who wish to collaborate and contribute to an Hg-free mining project.

One challenge will be to ensure that participating ASGM miners follow the correct mining procedures in terms of mine development (incl. prospecting) and use of equipment, to minimize chances of disappointing returns and subsequent loss of trust in Hg-free mining. The main challenge, however, is legality. The AGC wishes to work within a legal framework and at this moment there are virtually no ASGMs working within the boundaries of the Mining Decree. Through collaboration with Surgold and the GoS, the AGC may be able to solve this debacle.

COUNTRY MAP AND KEY STATISTICS

Figure 1. Map of Suriname with its districts. All visited mining areas were located in Brokopondo district.

Source: www.surinamewebquest.nl

Table 1. Fact sheet Suriname

Variable	Value
General	
Total Population (2012)	558.773 (ABS 2014)
Land area	163,820 km^2 (ABS 2013)
Economic	
GDP, billion USD	5.4 billion USD (CBvS 2016; 2015 data)
Real GDP growth	1.5% (CBvS 2016; 2015 data)
GNI per capita (USD)	US$ 9,509 (CBvS 2016, 2015 data)
Human Development Index value/HDI rank	0.714/103 (2010 UNDP, 2015)
% of population in severe poverty	2% (2010 UNDP, 2015)[1]
% of population in near poverty	4.7% (2010 UNDP, 2015)
Hourly minimum wage	Srd 6.14 (~USD 1.89)((GoS 2016)
Unemployment (number of persons)	10.745 (CBvS 2014)
Gold Mining , general	
State mining company (gold and construction materials)	Grassalco N.V.
Multinational mining companies active in Suriname	IAMGOLD (Canada) Newmont Mining Cooperation (US) Expected date of first production August 2016
Government revenue from mining (SRD Mln)	SRD 303 Mln (~US$ 93.2 Mln) (CBvS 2016. 2015 data)
Government mining revenue in % of GDP	1.7% (CBvS 2016; 2015 data)
Government revenue from gold mining as % of total government revenue from mining	58% (CBvS 2016; 2015 data)
Value of gold as % of exports	55.5% (CBvS 2016; 2015 data)
Value of gold exports in Mln USD	917 Mln USD (CBvS 2016; 2015 data)
Artisanal and small-scale gold mining (ASGM)	
Estimated number of ASGM (incl. services in mining areas)	11-15 thousand
Estimated percentage of Suriname population employed in (LS & SS) gold mining and spin-off activities	12% (Hammond et al. 2007)
Amount of gold produced by ASGM	18.9 tonnes (2015 data)
ASGM production as a percentage of total gold production	67.8% (2013 data; CBvS 2014)
Royalty on gold produced by ASGM	2.75%
Royalties earned from ASGM	9.6 Mln USD (~€7.2 Mln) (2013 data; Deviezencommissie 2014)

[1] No recent data available

1. INTRODUCTION

1.1 Study context and objective

This report describes the artisanal and small-scale gold mining (ASGM) sector in Suriname, with a special focus on the use of mercury. The study was produced in close collaboration with the Artisanal Gold Council (AGC), a Canadian Non-Profit Group focused on improving the livelihoods of those involved in artisanal gold mining throughout the developing world. The United States Department of State (USDoS) provided funding for this scoping and planning project in Suriname. The main objective of the study is to improve the understanding of the ASGM sector in Suriname and to assess the viability of, and develop plans for, future technical interventions focused on mercury reduction on active ASGM sites.

1.2 Methodology

1.2.1 Literature review

The consultant reviewed existing documents including academic studies, research reports, legal documents, websites, and newspaper articles. The consulted documents helped establish a more in depth understanding of the history of ASGM, the location and organisation of ASGM sites, mining styles and methods, the ASGM population, gold production and mercury usage, the gold and mercury supply chains and the legal framework. Study of secondary materials also guided the development of more focused questions to stakeholders, and provided initial ideas of the feasibility of technical interventions for mercury reduction.

Consulted data sources are listed in the references.

1.2.2 Expert consultations

Stakeholder consultations were conducted to complement, update and crosscheck the findings from the literature review. These interviews also served to make an inventory of what is already happening in Suriname with regard to Mercury reduction/elimination in the ASGM sector, and to discuss technical and logistic opportunities and challenges for a possible pilot project. In addition to persons directly linked to the gold sector, interviews also were conducted with individuals with a professional interest in mercury – particularly ASGM-induced mercury contamination. Table 2 presents a list of consulted stakeholders.

Table 2

Organization/Institute	Name	Function
Government		
Commission Regulation Gold Sector (OGS)	Mr. S. Benschop	Chair of the Management Team
Commission Regulation Gold Sector (OGS) (second meeting)	Ms. S. Punwasi Ms. R. Jagroe	Research and development team
Ministry of Natural Resources	Mr. Abeleven	Permanent secretary
Ministry of Natural Resources	Ms. Refos-Lalji	Sub-director
Geology and Mining Department (GMD)	Mr. B. Paansa	Chief Exploration and Geology
Currency Committee	Ms. N. Vaseur	Interim Director
Labour Inspection, Ministry of Labour	Mr. J. Courtar	Head of the Medical Office
Central Laboratory, Bureau Public Health	Mr. J. Quik	Head Chemistry Department
Central Bank of Suriname	Mr. Wolfram	Manager Corporate Affairs
Grassalco (state mining company)	Mr. H. Allendy Ms. A. Lalta	Advisor of the director Environmental Specialist
National Institute for Environment and Development in Suriname	Ms. G. Griffith	Legal advisor
Private industry		
Kaloti Suriname Mint House	Mr. W. Wilson	Director
Surinam Natural Stone (gold buyer)	Mr. B. Hoever	Director
Amazone Gold (gold buyer)	Mr. C. Issa	Director
Smaragd Mining (gold buyer)	Mr. W. d'Leon	Managing director
CKC Machinehandel SURMAC N.V. (i-con distributer)	Mr. R. Grens	Representative
Global Mining Solutions	Mr. J. Lansdorf	Suriname distributer
Nana Resources	Mr. H. Naarendorp	Former owner/advisor
Foundation for the Holders of Mining Rights	Mr. M. Naarendorp	Representative (also director Nana Resources)
Surgold	Mr. A. v. Kersen	Managing director
Educational institutes		
Anton de Kom (ADEK) University	Mr. D. Wip	Senior Lecturer Physics
Anton de Kom (ADEK) University	Mr. J. Quik	Lecturer Ecotoxicology
School of Mining and Mineral Processing (SMMP)	Mr. J. Courtar	Chair
School of Geology and Mining Technology (SGMT) of the Univ. of Applied Science and Technology	Mr. G. Geerlings	Chair
Other		
Conservation International	Ms. E. Misiekaba	Technical coordinator
U.S. Embassy	Mr. J.P. Winston	Political and Economic Officer
U.S. Embassy	Ms. B. Chandoe-Ramdjanamsingh	Economic assistant

1.2.3 Field visits

The AGC and Social Solutions visited the following ASGM sites in Suriname: Bewojo (2 days), Koffiekamp (2 days), Jebakai, Witikreek, Baleng, Kriki Neygi, and Companiekreek. These sites were selected because they are easily accessible, while all mining methods used in other locations in Suriname are present and can be observed.

At each site, the researchers conducted interviews with both local and migrant ASGM miners. During these interviews we asked about gold processing methods, with a particular focus on mercury use. With regard to mercury use, we asked about mercury acquisition, the quantity of mercury used per mining cycle and the duration of such as cycle, the moment(s) and location of placing mercury during the processing cycle, and the amount of mercury earned back by squeezing the amalgam and burning. Two ASGM equipment owners who (had) worked with reduced mercury systems were interviewed in Paramaribo. One of these individuals had worked with an i-con concentrator in as part of an Hg-free mining promotion project from the mining firm Surgold[2], and was able to provide feedback on this system. The other person was a mining title owner and (former) CEO of a well-organized and documented mining firm in South Suriname, and was able to provide crucial data on ore grades, recovery rates and other technical details.

In addition, the team conducted physical (crude) measurements of water velocity (through sluice box) and amount of ore processed by different teams to obtain a better understanding of (possible) ore grade, throughput, and recovery rates.

1.3 Outline of the report

In the remainder of this report we will proceed as follows;

This introduction is followed by Chapter 2, which describes the history and current situation of the ASGM sector in Suriname, including the population size and make-up, and mining regions. The next chapter, Chapter 3, describes mining styles and methods used in Suriname. It also discusses the current use of mercury and suggests simple adjustments to currently-used ASGM processing techniques to radically reduce or even eliminate the use of mercury. Chapter 4 discusses the government vision on ASGM, based on interviews with various government officials. The gold and mercury marketing chains are described in Chapter 5. The next chapter, 6, lists the most relevant stakeholders in the ASGM sector, including government agencies, private industry, and educational institutes. This chapter is followed by a discussion of relevant laws and regulations for gold mining and mercury use in Chapter 7. Chapter 8 discusses different methods that can be used for developing an inventory of gold mining and mercury use in Suriname, and presents initial, rough estimates. The report concludes with a brief synthesis of the findings and the implications for work of the AGC in Suriname.

[2] Surgold is the Suriname subsidiary of U.S. based mining multinational Newmont

2. SMALL-SCALE GOLD MINING IN SURINAME

2.1 History of small-scale gold mining

The first recorded official exploration for gold in Suriname occurred in 1718. It was followed by various private and state initiatives to explore and exploit Suriname's gold deposits (Bubberman, 1977). Like many other countries in the America's, Suriname experienced a first gold rush at the turn of the previous century (1890-1910). However, attempts to introduce heavier machinery failed at this time due to mechanical problems, improper planning, and erroneous cost calculations (Heemskerk, 2000). By 1908 production peaked at 1209 kilograms per year and then began to decline (Healy and Heemskerk, 2006). No data are available on the first use of mercury in Suriname but it is likely mercury was already used during this first gold rush.

The gold industry collapsed after 1908 due to the lack of management expertise, ineffective exploitation, widespread illegality, tensions between workers and concession holders, and the freezing of the gold price on the world market (Dahlberg in Heemskerk, 2000). Rapidly rising gold prices in the 1970s inspired renewed interest in the gold deposits of Suriname. In 1978 the Geological Mining Service of Suriname introduced small suction dredges on the Lawa River, then a new mining technique. Yet all governmental geological activity in the interior ended abruptly during the interior war (*binnenlandse oorlog*; 1986-1992). The interior became inaccessible, and the Jungle Command confiscated the governmental river dredges (Heemskerk, 2000).

After a Peace Treaty ended Suriname's interior war in 1992, the interior became once again accessible and both small-scale gold miners and large-scale companies returned to Suriname's gold deposits. The new boom in small-scale gold mining activities was driven by political and socioeconomic developments in Suriname, as well as the changing political and environmental climate in Brazil. Suriname's interior war had destroyed much of the socioeconomic and educational infrastructure in Suriname's interior. Small-scale gold mining became an attractive income generating activity for Maroons in East Suriname; the area that had been hit hardest by the interior war and hosts the largest share of country's gold deposits (Heemskerk, 2000). Around the same time, increasing numbers of Brazilian miners (*garimpeiros*), who were confronted with more stringent restrictions on small-scale gold mining in their own country, moved into Suriname (ibid.). Nowadays *garimpeiros* and Maroons dominate the small-scale gold mining sector but most concessions are in hands of the urban political and economic elite. These concessions include areas that Maroons traditionally consider as their tribal homelands, and to which they claim customary rights. Differences in culturally and legally defined property regimes occasionally leads to tensions about the access rights of different user groups involved (Heemskerk and Duijves, 2013).

A Commission for Regulation of the Gold Sector, hereafter called Commission OGS, was installed in January 2011 with a mandate to re-establish government authority in small-scale gold mining areas in Suriname. The vision and activities of the OGS are described in greater detail in Chapter 4.

Figure 2. Important dates in Suriname's recent history of gold mining overlaying gold spot price chart

2.2 Gold production and importance for the Suriname economy

In Suriname, two-thirds of gold is produced by small-scale gold producers rather than by multinational mining firms. Of the 27.8 tonnes of gold that were produced in Suriname in 2015, 18.9 tonnes of gold were produced by ASGM (Table 3). All gold produced under the caption Large-Scale Gold Mining (LSGM) came from the Rosebel Gold Mines N.V. (RGM) project of IAMGOLD in Brokopondo district.

Table 3. Production and export value of gold from ASGM and LSGM

	2009	2010	2011	2012	2013	2014	2015
Production volume LSGM (Kg)	13262	13359	13096	12961	11371	10,639	8,925
Production volume ASGM (Kg)	17905	19652	20830	22722	23976	20,142	18,852
Total gold production (Kg)	**31167**	**33011**	**33926**	**35683**	**35347**	**30,782**	**27,777**
Share of ASGM in production (%)	57.4%	59.5%	61.4%	63.7%	67.8%	65,4%	67.9%
Import value LSGM (x mln USD)	72.9	72.2	81.3	122.6	116.2	99.5	
Export volume LSGM (Kg)	12,512	12,606	12,247	12,829	10,641	10,850	
Export volume ASGM (Kg)	17,052	18,716	19,838	21,640	22,091	19,183	
Total gold export volume	**29,564**	**31,322**	**32,085**	**34,469**	**32,731**	**30,034**	
Export value LSGM (x mln USD)	385.0	486.5	599.3	666.7	479.1	438.3	
Export value ASGM (x mln USD)	486.9	673.2	914.3	1.056.016	940.3	735.4	
Total export value (x mln USD)	**871.9**	**1159.7**	**1513.6**	**666.7**	**1,419.4**	**1,173.7**	
International gold price in USD per troy ounce	973	1225	1569	1669	1411	1266	1160

Source: Central Bank of Suriname, Annual report 2014

In 2014, the Suriname state earned 7.5 million USD in royalties from the ASGM sector alone (Central Bank, 2015). Furthermore, in 2013, gold exporters paid 14.3 million USD (47.3 million SRD[3]) in export taxes (*consentrecht*). In the fourth quarter of 2013 the government of Suriname introduced an environmental

[3] At an exchange rate of 1 US$ = 3.30 SRD (IMF 2014)

tax for small-scale gold producers, which generated a total of USD 30,573 for the government in this quarter (Deviezencommissie, 2014).

2.3 Current ASGM situation: ASGM population size and composition

Estimates of the size of the ASGM population vary. A decade ago, Healy and Heemskerk (2005) estimated the total number of ASGM operations at between 800 and 1200, which would translate to about 10-15 thousand inhabitants of mining areas (incl. service providers), which still seems a decent estimate. In 2009, Suriname ASGM expert C. Healy calculated that the total ASGM population, including the service sector in the interior, counted between 10,000 and 11,000 individuals (Healy, 2009). This estimate was obtained by dividing Suriname's mining regions into 28 mining zones, and estimating the population size per zone. The consulted chair of the OGS management team estimated the total size of the ASGM population today at about 10-12 thousand, including the service sector (S. Benschop, chair OGS Management Team, pers. com. 06/05/16).

About two-thirds to three-quarters of ASGM are foreign gold miners, mostly Brazilian *garimpeiros*. Smaller numbers of foreign gold miners come from Guyana, other Latin American countries and in exceptional cases from elsewhere. Personal observations of the consultant suggest that the number of women working in the ASGM has increased over the years, and is larger among migrants than among local people. Women are most prominently present in the mining service sector as traveling saleswomen; shop owners; hairdressers and beauticians (e.g. nail salons); owners and managers of hotels, bars, restaurants and brothels; cooks; sex workers; transport providers (e.g. ATV driver) and so forth. In addition, women may be equipment owners and managers, or be present as the wife of the equipment owner or one of the workers. Counting women in these various professions, they may constitute 15-20 percent of the ASGM population (incl. service sector).

It is not uncommon for women to take their babies and infants to the mining areas, but when these children get to be school-aged, they usually leave the mines to attend school - either in the interior or in Paramaribo. In mining areas along the Suriname-French Guiana border, it has also been observed that migrant miner families send their children to school in French Guiana (e.g. Maripasoula).

Child labour is uncommon (Heemskerk and Duijves, 2012). Particularly in locations where gold deposits are located near a traditional village, local children (almost only boys) of elementary school age (6-14) may be seen panning the tailings. They usually work on weekends, after school, or during school holidays to earn some pocket money and help out at home. Only very rarely do young children structurally leave school to work in mining. Older children (15-18) are slightly more likely to work in ASGM, but also their numbers are low. They are typically Maroon boys who no longer go to school and, in the absence of alternative employment or educational opportunities, travel with an older brother or uncle to the mines. These teenage boys usually start with light jobs such as cooking, and gradually get involved in heavier mining related work. In this context, it is important to realize that in Maroon culture boys of 15 and older are considered young men with social and financial responsibilities.

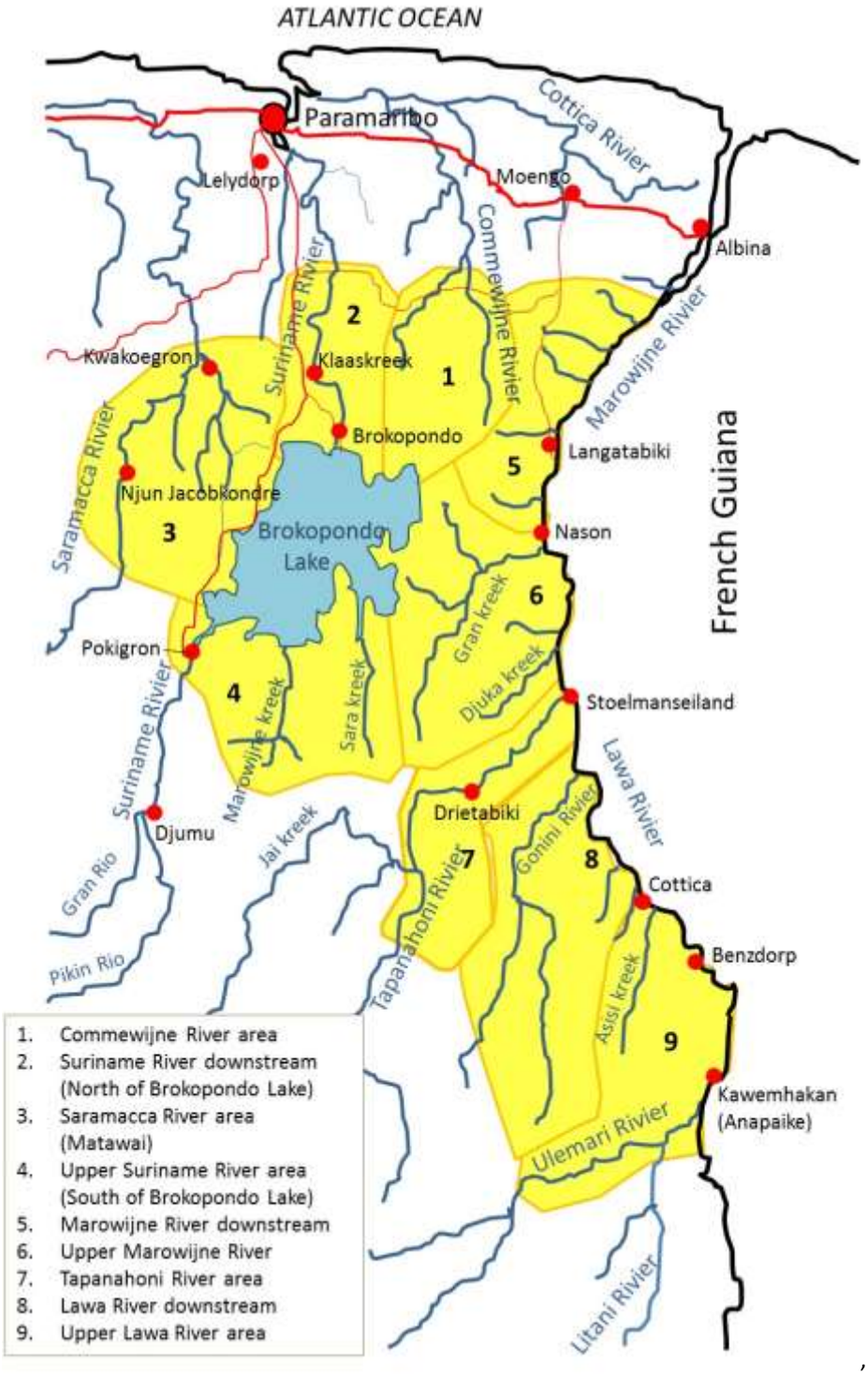
2.4 Mining locations

Suriname's gold deposits are part of the Guyana shield, a geological formation that stretches out across 415,000 km^2 of Venezuela, the Guyanas, and Brazil (Heemskerk 2009). In Suriname, the Greenstone belt covers 24,000 km^2 of Central-East Suriname (Figure 21). This is also the area where most ASGM takes place. In the past five years, we have not seen a significant reduction in ASGM activities, despite a lowering gold price and exhaustion of easily accessible ore supplies. A recent REDD+ report suggests, based on satellite imagery, that gold mining induced deforestation in Suriname has doubled between 2008 and 2014, as compared to the 2001-2008 period (+97%) (Rahm et al. 2015).

Dividing ASGM areas on the basis of watersheds, we can distinguish about nine "mining areas" (Figure 3). This subdivision is rather arbitrary and one could distinguish more or fewer gold mining districts or zones on the basis of other criteria. Suriname's map of mining concession is not public and despite various requests, the consultant was unable to see or obtain a copy of the map.

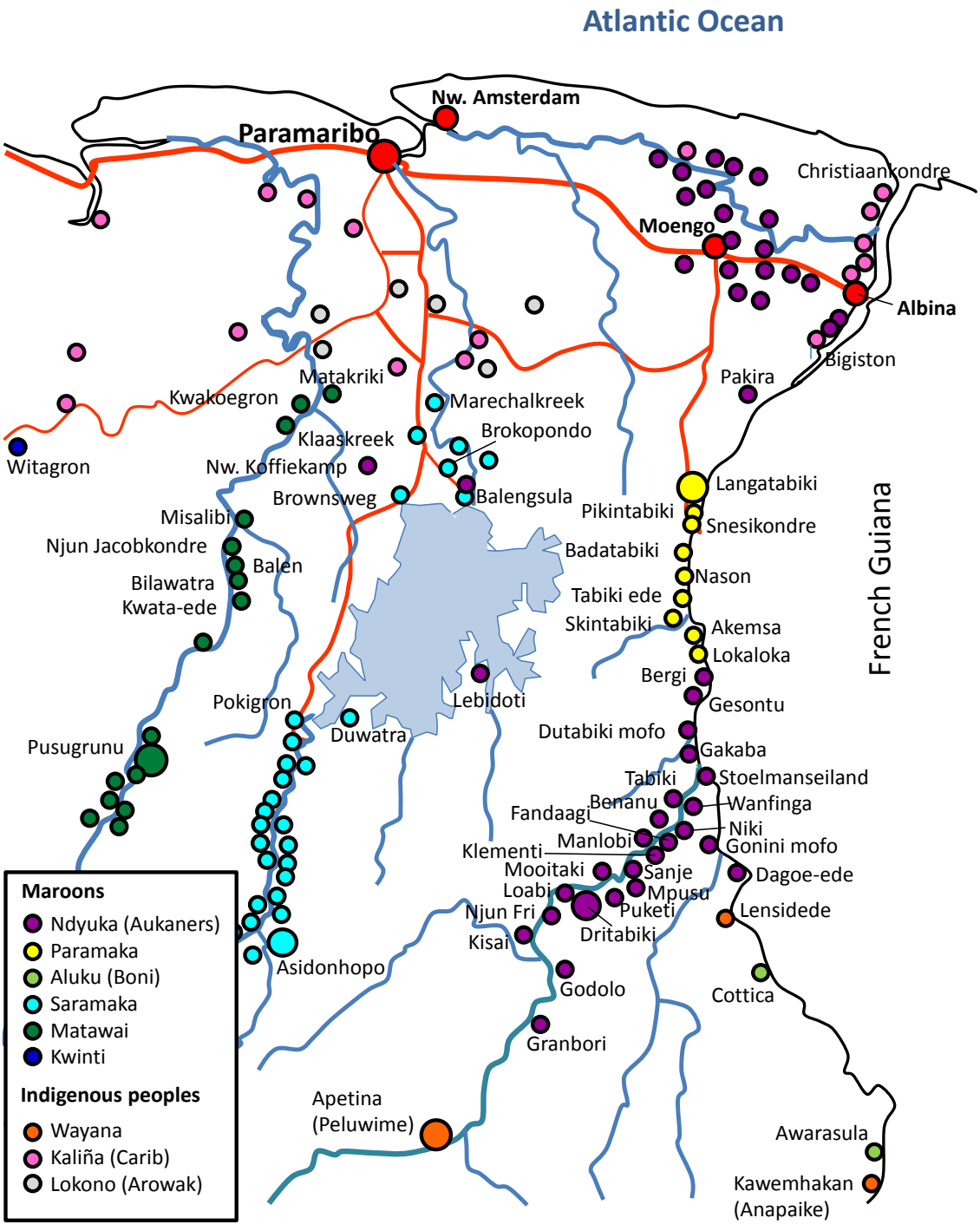
Many mining areas overlap with the living areas of Maroons; tribal forest peoples of African descent, and to a lesser extent Indigenous peoples (Figure 4). In fact, the largest share of Suriname ASGM, though only a small proportion of the mining title holders, are of Maroon descent.

Figure 3. Main mining regions in East Suriname



Source: adapted from M. Heemskerk 2009

Figure 4. Location of interior villages by ethnic affiliation



Source: M. Heemskerk 2009

2.5 Organization of ASGM sites

Virtually all locations where ASGM work are either part of a formal concession –either titled to a multinational company or to a Suriname firm or individual- or part of a traditional Indigenous or Maroon land claim. ASGM typically recognize these claims and comply with the regulations imposed upon them by the official or de-facto mining title holder or land lord. Problems sometimes arise where there is more than one land claimant. In addition, there have been a few cases where land is occupied by ASGM who do not recognize third party rights. The various organizational models of ASGM sites are summarized in Table 7, and described in greater detail below.

Formal mining title holders are people with a mining title extended by the Ministry of Natural Resources, either directly or through the Geology and Mining Department (GMD). The various types of mining titles are discussed in Chapter 3. Regardless of whether or not the mining title holder operates a mining plant, the largest share of the concession is typically sublet to independent ASGM. The equipment owners who sublet typically have to pay 10-12 percent of their gold to the concession owner. In order to make sure that the equipment owner pays his dues, he or she may only wash the gold concentrate in the presence of security staff of the concession owner. In some cases, concession owners have started to ask fixed fees instead of a percentage. Not only the gold miners, but also mining service providers such as shop and brothel owners are often obliged to pay the concession title owner or land lord; usually a fixed fee.

In exchange for payment to the mining title holder, the equipment owner is allowed to mine on the concession, and people who do not pay are evicted by security staff. By law, the equipment owner is not allowed to sublet the concession and Mr. Benschop, head of the OGS management team, acknowledged that concession subletting is a violation of the mining title conditions (S. Benschop, head OGS Management Team, pers. com. 06/05/16). In practice, however, this practice is tolerated by the Government of Suriname (GoS). Moreover, migrant Brazilian miners like this system because they know it from Brazil and it provides them with a sense of legitimacy. In addition to allowing the equipment owner to work, the mining title holder may provide additional services or place additional demands on the equipment owners. For example, a title holder may provide security and maintain the main roads, or demand that all fuel and/or groceries are bought from the mining title holder. Mining title holders typically hire armed security staff to enforce compliance with their regulations, including fee payment. In the case of serious offenses the national authorities are called in for assistance. Government authorities, notably the OGS, are occasionally called upon to evict unwanted ASGM.

Traditional or customary land claims are territorial claims on the basis of historic indigenous or maroon tribal residency in, or use of, a specific area. Under Suriname law, Indigenous peoples and Maroons do not have any formal rights to the land they live on and use for livelihood activities. Nevertheless, the various tribal groups and clans within these groups claim specific land areas, which are widely known and respected within and among the tribal groups. Members of traditional communities may, like legal title holders, ask ASGM on their territory to pay a concession fee; usually 10 percent but in some places or contexts less.

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Table 7. Different organizational structures under the different mining title claims; the regions refer to Figure 3.

	Mining rights of multinational firms	Concession sub-letting	Tribal land claim	Occupied zone
Example	Rosebel (Iam Gold; Region 2) and Merian (Surgold; Region 5)	All regions	Sella Creek (Region 7); Companie kreek (Region 2)	Roma pit (now evicted) (Region 2)
Basis of ownership claim	Mineral agreement between Ministry of Natural Resources and firm. Mining firm cannot legally permit the presence of ASGM	Mining Decree of 1986 and legal mining title. Subletting violates the mining title conditions, but is not actively controlled or punished by the government.	Customary land claims based on tribal regulations and families' presence in, and use of the area. These tribal claims have no national legal basis and may overlap with formal rights	ASGM occupy an area but do not recognize a land title owner – even though they typically work within the concession of a formal right holder.
Management and level of control	ASGM are not allowed within the boundaries of the Right of Exploitation. Nevertheless, they may (temporarily) not be evicted for the sake of preventing social unrest. Relations with ASGM are managed as part of a Social Responsibility or Community Relations Program	From high to low. Some concession owners have a strong presence; they function as a "landlord" who exercises control and/or have an own operation. Others are absentee permit holders and exercise little or no control.	Medium. Chiefs and family heads typically collect concession fees. In some locations tribal land lords are area managers who decide who may, and who may not work in the area. In other cases they exercise little control.	Low level of organization. Little structure and considerable degree of chaos.
Concession fees	Multinational firms will not ask ASGM for payment, but where their Right overlaps with tribal lands, local people may demand payment of fees from ASGM in the area.	Typically 10-12% to legal concession holder, but sometimes fixed fee. One mining title holder "employs" the ASGM on his concession and "pays" them a wage of ~87.5% of what they find in gold.	5-10% to tribal land rights holder. ASGM who are members of the same tribal group tend to pay nothing or a smaller voluntary contribution to the tribal land claimant	Nothing, or fee collected by a powerful individual.
Authority and sanctions	Security staff guard the area and where needed request ASGM to leave. Multinational firms rely, by law, on the government of Suriname (OGS, police) to physically evict ASGM who refuse to leave voluntarily.	Mining title holders typically have their own armed security staff to enforce rules and evict ASGM who do not comply. Authorities are involved in the case of serious offenses. In some instances, mining title holders request the GoS to evict ASGM.	Medium, safe-guarded through clan relations. The tribal land claimant may carry a weapon, usually a hunting rifle, or hire armed guards. National authorities are involved in the case of serious offences.	Low; different ASGMs or ASGM groups work on their own account. An individual with social standing or power of arms may interfere to resolve conflicts.

Source: Adapted from Healy and Heemskerk, 2005

Because tribal customary land claims are not recognized by law, they may – and often do – overlap with mining (and logging) rights that have been granted to third parties.

When a gold miner starts working on land claimed by a tribal group, either on his own account or on the invitation of a tribal land claimant, he will be requested to pay a concession fee. Since the land is not personal but communal property, tribal regulations dictate that this money belongs to the entire clan. In practice, however, the money is usually pocketed by the person who collects it. Foreign and outside ASGM typically pay to tribal land claimants as it provides them with a sense of legitimacy. Locals from the same tribal group often do not pay, either because they are not requested to pay or because they refuse to do so. Where the customary land claim overlaps with a government granted land claim, ASGM may be asked by both parties to pay the concession fee. This also happens when two families or individuals within a family claim the same area

3 MINING STYLES AND METHODS, USE OF MERCURY AND MERCURY-FREE TECHNIQUES

This section describes the most common mining styles and methods used by artisanal gold miners in Suriname. Almost all methods use gravity concentration. We are not familiar with the use of cyanide leaching among ASGM in Suriname. Also virtually all mining operations use mercury, as discussed in section 3.9. The final section of this chapter discusses the reduction of mercury by simple adjustments to current processing systems.

3.1 Hydraulic pumps (spoiti soigi) and a sluice box

Figure 5. Hydraulic mining

A common mining method in Suriname is hydraulic mining with a 4, 5 or 6 cylinder engine pump system. The pump is connected to about two or three (~7.5-15 cm) hoses: one or two hoses to divert water and create a slurry (Figure 5) and a suction hose to suck up the slurry (Figure 7).

The other primary piece of equipment is the sluice box or simply "sluice" (Sur: *daal*). Sluices are inclined, flat-bottomed troughs that are lined on the bottom with a trapping mechanism to capture particles of gold and other heavy minerals. They are typically self-made on the spot. In Suriname, most common is the zig-zag sluice (Figure 6) of roughly 1-1.5 m wide and 5 m in length.

The lining typically consists of a type of carpet with plastic fibres (Sur: *moket* or *moketi*; Por: carpete), which is kept in place by mesh wire (Figure 6). Ore is mixed with water to create a slurry, and the pulp poured down the trough. Heavy material (gold and sulfide minerals) sink to the bottom of the flowing water, becoming trapped in the fibres of the carpets.

It also occurs that the ore is transported to another location to be washed. This method is not common and mostly used in locations where mining in strictly forbidden. At Brownspark National Park, for example, ASGM take away ore in truck loads.

Figure 6. Sluicebox, with close-up of the trapping system

Figure 7. Suction hose (operation w/o excavator

Without excavator: Mining teams using the pump system without an excavator rely on the hydraulic power to remove the top soil, and in a later stage the ore. Miners working with a small pump typically do not continuously work with an excavator, but may hire one by the hour.

Mercury may be added in different stages of the mining process; often in the canal (which carries the slurry to the suction hose) and in the concentrate, and less commonly in the sluicebox.

Figure 8. Hydraulic mining with excavator

With Excavator: Mining teams with an excavator use the excavator to first remove the top soil, which is not washed, and next pile up the ore. The excavator may also be used to remove forest cover. Using an excavator, much more material can be processed, as no time is being lost in spurting away the top soil. Moreover, the ore is concentrated in one pile. Mining teams that do not own an excavator may also hire an independent operator by the hour, which will cost about 5-10 gr Au/hr, depending on the location.

3.2 Hydraulic mining with screen (Sur: isri daal)

Figure 9. Use of a screen in hydraulic mining

In a few locations, ASGM teams use a large vertical screen panel (e.g. Grizzly screen), fabricated of steel or wood, to sieve the ore. In locations with a lot of pebbles and stones this system is used to separate the larger rocks (which stay behind) from the finer material (which is washed). Also people who mining river beddings often use a screen to separate the gravel (waste) from the small particles. This system makes use of two spurting hoses, which spray the material through the sieve, but no suction hose. The *moket*, mounter on a piece of board or metal plate, is placed on the ground.

Teams working with a mining screen typically use two excavators. One excavator is used to mine, while the other excavator places the ore on top of the sieve, and cleans up below (the larger pieces). In addition, one person, the oiler, works between the two excavators. It also is possible to use an additional pump to suck up the tailings from the sluicebox behind the screen, and guide them to a second sluicebox. Mining with a screen is not common.

Figure 10. Ground sluicing (Sumajé)

3.3 Ground sluicing (Sur: Sumaje)

Small hydraulic pumps (between 1" and 3" pumps) can also be used on hill-sides, using a *sumaje* system. This system can be practised to mine colluvial deposits, alluvials, or tailings. One person loosens up the material with a pick axe, or digs up material (e.g. tailings) with a shovel. A spurting hose is used to create a slurry, which subsequently runs downhill onto the mats, which are mounted on a piece of board in a narrow trough. Riffles may be used to keep the mat in place but are not common.

In this system, miners typically work in teams of two, sometimes or occasionally alone. Observations suggest that this system is mostly used by local area inhabitants and hardly by migrant ASGM or ASGM from Paramaribo.

3.4 Long tom

A slightly more advanced variation on ground sluicing uses the long tom. A long tom is a long, narrow sluice box, which is mounted on a stand to get the preferred angle. It is used for both colluvial and alluvial ore. A shovel is used to place ore in a box on top of the highest end of the long tom.

Water is spurted in the box, to push the ore through the sieve on the bottom of this box. The box is lined with a mat, which is held in place with riffles. Mercury is usually placed just below the sieve and before the riffles, where the water spins. Observations suggest that this system is very rare, and if used, mostly by local area inhabitants and hardly by migrant ASGM or ASGM from Paramaribo.

3.5 Crushing and grinding (Comminution)

Virtually all crushing occurs mechanically, using a hammer mill[4]. The crushed ore goes to a collection container (SUR: *crusher bakkie* or *brandkas*). Crushers are used to increase liberation of gold from other partices, allowing increased amalagamtion of gold with mercury, and thus increasing gold recovery. An amalgamation box is often placed directly following the crusher. It is in this box that mercury is added, and all material leaving the crusher must first pass through this amalgamation box.

Figure 11. Crusher operation with three crushers in a line up

[4] One case is known of a Chinese miners who used a ball mill, but the system did not work well and he abandoned it.

The box will usually have multiple compartments in which material accumulates, passing once it overflows. Heavy material (eg. Mercury and gold) remain in the box while lighter material is washed over the containing sides of the box. The overflow of these boxes typically flow onto sluices for further concentration of gold. Many crusher users place a copper plate after the amalgamation box or between sluices. The copper plate is rubbed in with mercury so that the gold particles –flattened by the hammer mill, easily stick to it. However, since the copper plates are often stolen, they now they also use other methods.

Manual crushing is uncommon in Suriname. Miners may apply this method when, for example, the mining multinational Iam Gold blasts dynamite. ASGM will enter the blast site to get a couple of large rocks, which are taken away and subsequently grinded manually using an iron pot and an iron rod as a mortar-and pestle.

Figure 12. Panning

3.6 Panning

Panning is used for prospecting, but also occasionally as the primary means of gold concentration. As a primary income source, panners (Sur: *baté-mans*) seek out rich tailings and creeks. Panning is typically a one-man business, though sometimes groups of panners live together. People who pan as their primary business are usually local area inhabitants. In addition, school children who live in communities near mining areas may pan after school or in weekends and school holidays to earn a little pocket money.

Panning is also the preferred work method of gold miners who take and wash the ore of others. This (much despised) practice, locally referred to as *ukum*, was observed in different locations, typically performed by local Maroons. For example, in Companiekreek panners hang around the tunnels of Brazilian mining crews, to scoop up ore that falls out of the buckets that are hauled up from below. The ore is collected in bags and taken to a nearby water source to wash. In the mining pits of Rosebel N.V., *ukum* miners collect ore in bags after dynamite blasts, and take it away to pan elsewhere.

3.7 Metal detectors (pew-pew)

Metal detectors are used by individuals to look for gold nuggets. They may be a tool in prospection, but are also used as a low capital intensive primary income source. The size of nuggets that can be detected and the depth to which they can be detected depends on the power of the device. As a primary income source, *pewpew* operators (Por: *pewpewzeihros*) often target either the tailings or stockpiles of other operations, which sometimes causes conflict with mine operators. Because of their mobility, metal detector users also work in areas where SSGM is forbidden, such as protected areas or the concession areas of large mining operations.

Figure 13. Gold miners with metal detectors

3.8 Mining on river dredges

ASGM in Suriname use rafts or dredges to mine river sediments. The smaller type, locally named *ponton* or *pondo*, is operated manually. Divers, who receive air through a narrow hose, take the suction hose and move it across the river bottom. They may stay under water for about 4 hours at a time. As with the regular hydraulic mining on land, a pump sends the slurry to a sluice, which is mounted on the raft. The tailings flow into the river. A consulted dredge owner indicated that using this system he found as much gold in 20 hours (not in sequence) as he would find on the land in a month's time.

A larger and more advanced version of this system is the *skaljan*. In this system, the suction hose is mechanically operated from the dredge and does not need divers. The dredges typically contain all necessities for the miners, including sleeping huts and a kitchen. These large dredges may process 200-300 m3 ore/hr. While the investment in an automated river raft is relatively high (0.5-1 mln. USD), the earnings also tend to be considerably higher than in land-based operations.

In dredging systems, mercury tends to be added in the concentration phase. It is uncommon for miners to place mercury in the sluice box.

Figure 14. River draft (ponton)

Figure 15. Automated river raft (skaljan)

Table 4. Characterization of ASGM mining methods used in Suriname

Method	Suriname term	# workers per (12h) shift, excl. cook	Division of earnings**	Capital investment***	Use of mercury*
Hydraulic pump without excavator	*Spoiti soigi, sondro pokline*	~ 6 total: two workers with spurting hose, one worker with suction hose, two workers collect stones. One supervisor (Por: *gerente*).	Owner 70%, workers 30%	30,000-40,000 USD	++
Hydraulic pump, with excavator	*Spoiti soigi nanga pokline*	~ 6 total. 5 workers: two work with spurting hose, one with suction hose, two collect stones. One excavator operator. One supervisor.	Owner 80%, workers 20%	80,000-150,000 USD	+++
Hydraulic pump, with excavator and screen	*Isri daal*	~ 5 total: 2 workers with spurting hoses. 2 excavator operators. One supervisor	?	150,000-200,000	+++
Ground sluicing	*Sumaje*	1-2 total: 1 with spurting hose, 1 removes large stones	Owner 80%, workers 20%	600 USD	+
Long tom	*Long tom*	1-2 total: 1 with spurting hose, 1 feeds material	?	600 USD	+
Crushing	*Kroesjer*	~ 3 total: 1 worker with spurting hose, 1 worker feeds crusher and breaks stones, one supervisor. In cases where an excavator provides the ore; also 1 excavator operator	?	15,000-20,000 USD	+++
Panning	*Draai bate*	1	100% to owner	50 USD	+
Metal detector	*Pew pew*	1	100% to owner	1300 USD	0
Dredge, manual	*Ponton*	~ 2-4 total: 1-2 divers, 1 communicates with divers, 1 pump operator.	?	100,000 USD	+
Dredge, mechanized	*Skarljan*	~ 3-4 total. 2 operate (in turn) suction mechanics, 1 looks at sluice box	?	0.5- 1 mln USD	+
i-con(centrator) (with crusher)	*i-con*	~ 3 persons. 1 with spurting hose, 1 checks material flow to i-con, 1 excavator operator	Owner 80%, workers 20%	60,000 (without excavator)	0

* +++ = high Hg use; ++ = medium Hg use; + = low Hg use; 0 = no Hg use

** The cook usually earns a fixed wage of between 30-50 g Au/month. The operator also tends to get a fixed wage of ~ 80-100 g Au/month. When an independent operator is hired (with excavator), the expense is ~ 6-7 g AU/hr. These costs are deducted from the mine owner's earnings

*** All larger operations would require an ATV (~USD 10,000). An excavator costs USD 50,000 for a good condition second hand in the forest, or USD 80,000-100,000 for a reconditioned 2nd hand with a dealer. Building camp will cost about 1500 USD.

3.9 Use of mercury in ASGM

In a 2014 survey among ASGM, we found that virtually all ASGM admitted using mercury during the mining process (Duijves and Heemskerk, 2014). This finding was confirmed during consultations with ASGM in June 2016. At this time, the research team encountered only one gold miner in a small, one person hydraulic (Sumajé) operation, who reported that he had not bought any mercury in the past couple of months. Washing the tailings of earlier mining operations at his working location, he actually found mercury, which he collected during the mining process and re-used when necessary.

Gold miners working with a crusher system typically place mercury in the "safe" (*brandkast*); a metal container with riffles attached after the crusher. Consulted crusher operators reported placing between 1 and 4 kg of mercury in the crusher safe per cycle. If the system uses a copper plate, they may rub another ~ 200 gr of mercury on the copper plate during the mining cycle.

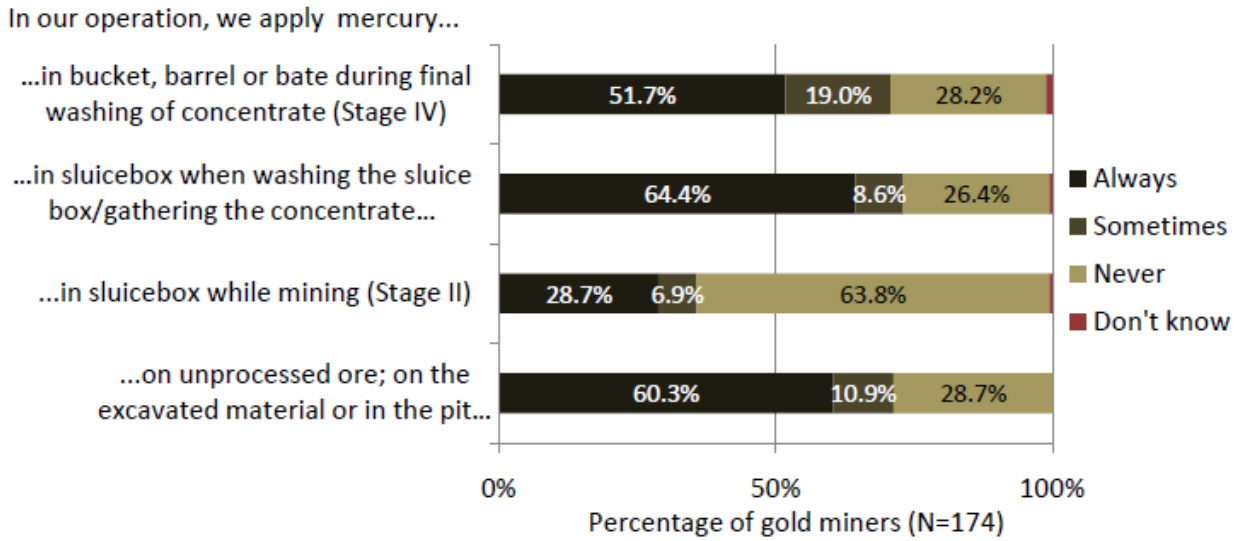
Because the mercury is heavy and not likely to flow (in large amounts) over the riffles in the "safe", it is likely that most mercury is found back after the mining cycle (~1 week day and night). Consulted crusher operators reported that by squeezing the amalgam through a piece of fabric, they would collect between 80-85 percent of the mercury again. This may be a desirable answer though, and without measurement we cannot know for sure how much mercury is recovered.

In sluicing (Br: *chupadeira*) systems, mercury is added during different stages of the mining cycle. In our 2014 study we found that almost three quarters of interviewed gold miners (all sluicing operations) reported whole ore amalgamation, where mercury was always or sometimes applied to the unprocessed ore[5]. The amount of mercury that is applied in an hydraulic operation depends mostly the amount of ore to be processed (ore ⇧ = Hg ⇧), ore grade (ore grade ⇩ = Hg/Au ⇧) and grain size of the gold (grain size ⇩ = Hg ⇧).

Because gold miners in the sluicing system add mercury continuously, it is very difficult to estimate the amount of mercury added during one cycle. One consulted user of a ground sluicing system estimated that his team added ~200 gr mercury to the ore during a one-week cycle. A larger operation with a zig-zag sluice and excavator reported operational cycles of five 24-h days. This operation would process 14 heaps of ore during one cycle, with ~200 gr mercury sprinkled on each heap. In the concentration phase, they would add another 100-200 gr mercury of necessary. These figures suggest that their operation would apply ~3 Kg mercury per week cycle. Another *chupadeira* owner reported adding about one or two bottle lids (~ 100 gr mercury/lid) every 2-3 days during a two week working cycle, for a total of about 500 gr/Hg per week. Additional mercury use rates reported by miners during surveys are included in Section 8.8.

[5] Whole ore amalgamation is probably only used with hydraulic systems; we have not heard of this method in crusher systems.

Figure 16. Stages in the mining cycle where mercury is applied



After gold miners collect the mercury gold amalgam, either by washing the carpets or by collecting it from the crusher *brandkas*, they squeeze the amalgam through a cloth. Excess mercury trickles through the cloth and is recovered. The exact amount of mercury gold miners find back by squeezing depends on the amount of gold they find, and consulted miners were not able to give a good estimate of what share of mercury they recycled by squeezing. The mercury amalgam is burned off using a wood fire or a burner. Many equipment owners (crusher and sluicing systems) reported covering the *batea* with large leaves when burning the amalgam. After burning, these leaves are washed in water to collect the mercury that sticks to them for re-use. This, however, is a small amount. Retorts are seldom used[6], neither is protective gear such as gloves or adequate face protection (Duijves and Heemskerk, 2014).

It is difficult to estimate how much mercury a mining team uses, let alone the Suriname ASGM sector as a whole. In Chapter 8 we make an effort to get to such an estimate, based on field consultations in June 2016.

3.10 Mercury free processing workflows

Given the rudimentary, inefficient, and mercury intensive processing workflows currently employed by ASGM miners in Suriname, there are many opportunities for the development of more responsible and economically attractive alternatives. Mercury free gravimetric processing systems have the potential to both eliminate mercury usage while simultaneously increasing gold recovery and processing capacity. The majority of mining groups in Suriname are already practicing some form of semi-mechanised gravimetric concentration, using excavators, generators, pumps, crushers and sluices in their operations. This suggests that the mechanical and electrical skills required to maintain and operate improved and optimized

[6] Our 2014 study suggested that even though two thirds of gold miners had heard of a retort, less than 10 percent used this device for burning the gold-mercury amalgam (Heemskerk and Duijves 2014)

gravimetric processing systems already exists. Proper system design, optimization and operator training could significantly improve the recovery and economics of the ASGM sector, while reducing environmental degradation and mercury emissions.

3.10.1 Current efforts to reduce mercury use

Several organisations and companies have attempted to implement improved gravimetric processing workflows to reduce, and where possible eliminate, mercury use during processing. These organisations range from small/medium-scale mining groups looking to maximise production while reducing negative environmental impacts (eg. Nana Resources and GRASSALCO), to educational organisations and small businesses looking to provide the expertise and machinery needed to reduce mercury usage while providing local economic benefits (eg. UNASAT, Lawa Star Industrial). These gravimetric processing workflows make use of similar processing techniques currently employed by artisanal miners, but with additional process control and concertation steps to allow for direct smelting of concentrates, reducing the need for mercury amalgamation. Similar gravimetric workflows have been developed by all three of these groups, all of which use some combination of the following processing equipment:

Excavator: Used to extract and transport ore in preparation for processing
Pumps and Hoses: Used to wash ore, produce a slurry, and transport ore to the onset of gravimetric concentration.
Mill/crusher: A milling system, usually a hammer mill, is used to grind coarse particles and liberate the gold. May or may not be used depending on grain size and gold liberation in the ore.
Grain size control: Grizzly bars, screens and or sieves may be used to sort and remove coarse material before the onset of gravimetric concentration.
Sluices: Sluices represent the first stage of gravimetric concentration and are used to capture heavy minerals including coarser gold particles.
Centrifuge: Centrifuges are used as a second stage of gravimetric processing, and are generally used on sluice tails in an attempt to recover the fine gold lost by the sluices.
Shaking Table: Shaking tables, waves tables, and finishing tables may be used following sluicing and centrifugal concentration to further upgrade concentrates to a point where direct smelting is possible.
Furnaces and Torches: These are used once a high grade concentrate has been produced to smelt the concentrate, forming a final gold doré.

An example mercury-free gravimetric processing workflow is shown in Figure 17. To date, very few sites have succeeded in completely eliminating the use of mercury. However, some have significantly reduced mercury usage by increasing concentration, and adding mercury only to the final high gold content concentrate. Mercury is added to this concentrate in a controlled and closed system, limiting loss to the surrounding environment, and containing mercury to within the closed system. The use of retorts to burn the amalgam significantly reduces mercury emissions; however, proper retort usage and storage is essential to avoid human exposure to mercury vapour.

Figure 17. A potential gravimetric workflow showing the various components of the processing system. D

To optimize recovery and eliminate the use of mercury a site specific gravimetric processing workflow is needed. This workflow could consist of the components of the system shown above, but in certain cases other equipment may be needed. In developing a site specific workflow the ore must first be assessed to understand gold grade, distribution and grain size, mineralogy, and metallurgy. Any processing workflow should take into account logistical requirements of transporting and installing processing equipment, as well as the needs and abilities of the mining group to operate, optimize, and maintain the equipment. Grain size control and gold liberation are areas with significant potential for improvement with respect to gold recovery in most artisanal mining workflows. Some processing workflows chose to crush ore prior to beginning gravimetric concentration to ensure liberation of gold from other minerals as required for gravimetric concentration. Not all material requires crushing, and the added value of crushing and milling must be studied for each ore type and processing workflow. It is possible that the economic return for recovery of this gold is not worth the increased costs and time for processing.

Gravimetric processing workflows present many economic, health, and environmental benefits to the miners and their surrounding communities. Discussions with MSM companies who upgraded their workflows from the rudimentary processing techniques applied by ASGM groups (spurting-suction-sluices with mercury) to improved gravimetric and mercury-reduced/free systems suggest that they have increased gold recovery from approximately 25 % to 50 % of the gold contained in the ore. This doubling of recoverable gold from an ore presents a significant increase in earnings to the groups. Properly designed systems could present similar increases to ASGM groups who adopt these processes. Additionally, the associated reduction or elimination of mercury use can have profound environmental and health benefits.

3.10.2 Suggested improvements to current workflows

Simple improvements to current processing workflows can result in significant improvements in gold recovery and mercury reduction. Grain size control prior to sluicing can ensure that a uniform grain size slurry enters the sluices, reducing concentration bias towards coarser and heavier sediments. Optimization of existing sluices (used by almost all artisanal miners) by adjusting water flow rates, sluice angle, and washing schedules, can produce an improved initial concentrate, and reduce gold loss to tailings. Fine gold missed by the sluices may be recovered using a centrifuge. Further concentration of sluice or centrifuge concentrates using a shaking table can further upgrade the concentrate to a point where direct smelting may be possible. Direct smelting can be completed using a small furnace or oxygen-acetylene torches. An estimate of the costs for standard shaking table and centrifuge purchases, and some options, are included in Table 5.

Table 5. Price comparisons for various gravimetric processing equipment

	ICon i350 Centri-fuge	**Falcon SB-400 Centrifuge**	**Chinese 6s Shaker Table**	**GMS RP4 Shaker Table**	**Gemini GT60 Shaker Table**	**Action Mining M7 Wave Table**	**Holman 2000 Shaker Table**
Price (USD)	~19,000	~35,000	~2000	~2,500	~14500	~7,500	~25,000
Through-put	10-15 T/hr	~1-15 T/hr	~400 kg/hr	~275 kg/hr	27-45 kg/hr	275-1100 Kg/hr	

The cost for the addition of an Icon i350 and a RP4 shaker table (currently used by SSM companies in Suriname), excluding shipping and installation costs, would be ~21,500 USD. Assuming 50% transport and installation costs, this totals ~32,250 USD. Taking an average throughput rate of 200 T/d, conservatively increased recovery rates from 25% to 35%, and ore grade of 1 g/T at 90% pure gold, increases in weekly miner earnings (5 days operational/week) would increase from 225 g to 315 g. At 40 USD/g, this increase is equivalent to 3600 USD/wk. At this rate, it would take ~ 9 weeks to pay off the initial investment with the additional earnings associated with the increased recovery. Of course, this simple calculation excludes any additional maintenance and operational costs associated with the new equipment, and uses assumed unproven increases in recovery. These calculations are meant only to provide an example of the potential economic incentives that exist alongside improved gravimetric and mercury-free processing systems.

3.11 Mine Planning

Lack of mine planning has been identified as a significant issue in the Surinamese ASGM sector, leading to widespread environmental degradation including deforestation and river siltation, inefficient resource extraction, limited gold recovery and general waste of resources. This poor mine planning includes both the exploration and production phases; however, the lack of cohesive exploration methodology has been identified as a particularly poor practice with significant room for improvement. Basic exploration programs can identify and define target ore reserves, and mine site planning can ensure that efficiency is maximised, and that only economically viable deposits are processed.

3.11.1 Exploration

Currently, exploration is limited to digging pits and assessing the ore once it has been exposed. This is largely done using excavators, which have high operational, maintenance and fuel costs. A simple exploration technique that could be applied makes use of hand augers to test ore at depth, without having to physically remove all overlying material. Alluvial deposits are typically very soft, and can be drilled using hand augurs. Depending on the hardness and grain size of the ore, depths upwards of 10 m can be drilled. By drilling to a set depth, following predetermined survey lines in a gridded fashion, and panning the material removed to determine if gold is present and at which depth, an understanding of ore bodies and gold distribution can be attained with significantly less expenses, time and effort than is needed using current exploration methods. Hand augers used for agricultural purposes armed with extensions for

increased depth can be purchased for less than 1000 USD. Additional costs beyond that are simply limited to the labour costs of workers conducting the auguring. Some basic training on exploration methodologies and strategies is needed for augur operators to ensure they follow survey lines and record appropriate information. Some basic survey planning, such as spacing of holes, hole numbering, and data recording methodology are needed; however, once training is completed this data can be recorded simply using a pen and paper, and does not require sophisticated equipment or knowledge.

3.11.2 Mine planning and remediation

Once an ore body has been identified, some simple mine planning should be done to ensure the ore is extracted and processed in a methodical and efficient way. Currently, much ore is lost due to poor mine planning. As material is excavated and moved in search of ore during exploration, and removed for processing during production, overburden material and tailings are deposited adjacent to the extraction site, often covering other potential ore bodies. Miners follow high grades by digging, testing and processing ore based on results of panning, in the process moving large amounts of material, burying untouched potential ore. This rudimentary exploration and processing practice often results in the reworking of the same material multiple times as it is uncertain what material was processed and what was not, as well as the burying of potentially economic and untouched ore. This entire process is very inefficient. A proposed mine management strategy is to identify an ore body by exploration. Once identified, a hole adjacent to the deposit should be dug, placing overburden in a region known to not contain economic deposits of gold. The identified ore body should be processed, with tailings filling the initial hole. As the mining advances, tailings should back fill the holes created during previous mining cycles. This is a method both to ensure future ore deposits are not buried with tailings, and provides some basic land remediation simultaneously alongside mining.

4. GOVERNMENT VISION ON ASGM AND MERCURY USE

4.1 Government vision on ASM

When the Bouterse–Ameerali government took office in 2010, it spearheaded a policy program to regulate the small-scale gold mining sector. Up to that time, the government had taken a largely *laissez-faire* attitude towards the sector. Apart from seemingly random "clean-sweep" actions, whereby the equipment of foreign gold miners without appropriate documentation was confiscated[7] and the owners sent to jail for a few nights, the government was hardly involved and did not have a clear ASGM policy vision.

The Commission for Regulation of the Gold Sector, hereafter called OGS (*Ordening Goudsector*), was installed in January 2011 with a mandate to reestablish government authority in small-scale gold mining areas in Suriname.

In an effort to fight illegality in the ASGM areas, OGS started with a gold miners' registration program, both in the interior and in Paramaribo city. Between 2011 and 2014, OGS registered 6343 individuals working in the ASGM sector (OGS e-mail conversation, 29/04/16). Among them were 3791 Brazilians, while the remaining registered gold miners and mining service providers were mostly Surinamese, and some individuals from other countries.

The OGS also is the main institution designing the government's vision and policy on ASGM. The Chair of the OGS Management Team reported that the OGS activities are guided by a Policy Plan 2015-2017 (S. Benschop, pers. com. 06/05/16). This plan is not public, but according to the consulted OGS official the three main pillars of the government policy vis-à-vis ASGM are:

1. Eradication of illegality
2. Tax collection
3. Mercury free mining

The second pillar of this policy, tax collection, is the primary responsibility of the tax department, and OGS plays a supporting role. The third policy pillar "mercury free mining" is left to the University of Applied Sciences and Technology (UNASAT), which already works on this issue (see stakeholder matrix Chapter 6). OGS supports this effort by making land available for field classes, by providing a mine inspector, and by providing security. OGS is not directly involved in mercury free mining projects.

The main policy interventions executed by the OGS focus center around policy pillar 1: eradication of illegality in the ASGHM sector. In order to reach this goal, the OGS will intensify registration efforts; guard problem areas; evict ASGM from locations where their activities are not allowed; and facilitate interventions by other agencies (e.g. Ministry of Health) in the area.

[7] Some days later the same gold miners could buy their confiscated equipment back from the police for some thousands of US dollars, and continue their activities.

Even though registration of ASGMs is a main policy intervention, the benefits for gold miners of being registered are unclear. The proof of registration (a paper slip) does not make one a "legal" gold miner (S. Benschop, Chair of OGS Management Team, pers. com. 06/05/16). Many ASGM did not register during earlier registration campaigns and those who did, did not experience benefits. In fact, some gold miners complained that the only result of registration was that they received a tax assessment summoning payment of several years of mining incomes -as estimated by the Tax Department. At the moment, the registration process has come to a virtual stand-still, but the Chair of the OGS management team asserted that registration will be restarted soon; both in Paramaribo and in the field (S. Benschop, pers. com. 06/05/16). Ultimately, the OGS wishes to legalize gold miners, but it is as of yet unclear how this will be achieved. The system of handing out (selling) "Miner ID-cards", which was started under the previous OGS Manager, has been temporarily halted because of "circumstances" (ibid.).

In different mining areas the Commission OGS has established Mining Service Centers (MSC). The initial thought behind the MCS was that at these locations, ASGM would be able to register and access services such as technical training, health services, and selling gold. The existing MCS do house rotating OGS staff to keep an eye on ASGM activity. However, apart from a one-time visit from, for example, health workers from the Bureau of Public Health (*Bureau Openbare Gezondheidszorg* - BOG), the provision of services has been limited.

Among the core activities of the Commission OGS has been the eviction of irregular gold miners from places where they are not allowed to mine and/or where their activities constitute a public or environmental hazard. In 2015, the former Chair of the OGS Management Team emphasized that in removing small-scale gold miners, the focus is on "dialogue and minimal use of violence" (Mr. Dompig, pers. com. 19 March 2015). Among others, the Commission OGS has removed small-scale gold miners from the concession areas of multinational mining companies, from the Brownsberg Nature Reserve, and from "Dam 10" – which provides flood-protection.

Challenges to the enforcement of government policy in mining areas include the remoteness of mining areas, high expenses of travel to the mining areas, the outdated mining law, and the personal interest of politicians in the mining sector.

4.2 Government vision on mercury elimination from ASGM

In recent years, the Government of Suriname (GoS) and national and international partner organizations have become increasingly aware of the necessity to take action to reduce and eventually eliminate the use of mercury in Suriname. As the primary source of mercury contamination, the ASGM sector has received most attention in policy planning around this theme.

In 2014, a number of public and private organizations established the Mercury Free Partnership (MFP). Current MFP members include Conservation International (secretariat), the Bureau for Public Health (*Bureau voor Openbare Gezondheidszorg* – BOG), the National Institute for Environment and Development Suriname (*Nationaal Instituut voor Milieu en Ontwikkeling Suriname*- NIMOS), World

Wildlife Fund (WWF)-Guianas, the Anton de Kom (ADEK) University of Suriname, and the OGS. MFP members meet monthly to share information and updates.

In 2013, NIMOS started a process to advise the government with regard to signature and ratification of the Minamata Convention on Mercury. This process included stakeholder consultations and resulted in an advisory document and a roadmap with activities for the gradual elimination of mercury from Suriname. Proposed activities include registration and legalization of ASGM activities in Suriname.

As per August 2016, Suriname had not yet signed the Minamata Convention on mercury, but it is in the process of taking this step. In June 2016, the council of Ministers approved ratification of the Minamata Convention. The proposal is now awaiting approval of the National Assembly (Mr. D. Abeleven, director Ministry of Natural Resources, pers. com. 21 June 2016).

Another policy initiative of the Ministry of Natural Resources in support of the reduction and elimination of mercury is revision of the Suriname mining law.

5. GOLD AND MERCURY MARKETING CHAINS

5.1 Gold supply chain analysis

5.1.1 Gold selling and buying early 1990s to 2002

In the early 1990s, at the onset of the second gold rush, many ASGM sold their gold to Chinese jewellery shops, which mushroomed in Central Paramaribo (Heemskerk, 2010). In addition, other businesses were buying gold or taking gold as payment for supplies. Both the Chinese jewellers and other gold entrepreneurs often illegally exported gold abroad, among others to the US (de Vries Robbé, 2004).

In 1994 (up to 2002) the Central bank of Suriname became the only official buyer of unrefined gold. One of the goals of buying gold was to sell it to jewelers, while another share was exported. In the initial years after implementation of this policy, the Bank paid too much for the unrefined gold because vendors regularly mixed it with other metals such as copper and silver. In 1996, the CBvS initiated the more structural purchase of gold, by giving twelve agents in and around Paramaribo city an exclusive license to purchase gold from gold miners in name of the CBvS. The agents were obliged to sell all the gold they purchased to the Central Bank.

Gold was melted and purified in the gold lab of the Central Bank. In order to collect royalties, the Bank purchased gold without consideration of the legal status of the gold miners or the origin of the gold (i.e. what country or what concession). In doing so, the Bank and the Suriname government de facto tolerated unlicensed mining (*gedoog beleid*). This system was criticized by the Auditor General (*President van de Rekenkamer*) who was of the opinion that this system endorsed illegality and uncontrolled gold mining (Pollack and de Rooy, 2000, in: De Vries Robbé, 2004).

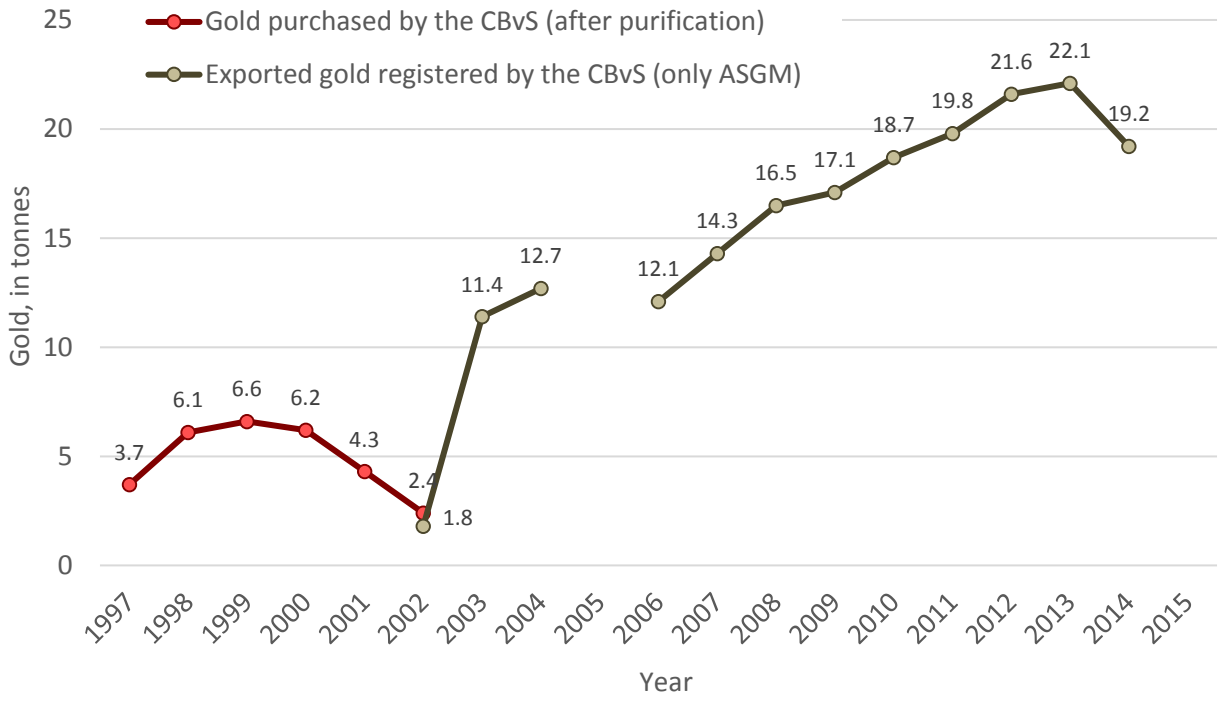
In 1997, the CBvS made an effort to stimulate the legal purchase of gold by lowering their provisions from three to one percent (de Vries Robbé, 2004). This policy led to a temporary increase of gold purchases (Figure 18). In 1998, 6.1 tons of gold were bought; an increase of ca. 65 percent in comparison with the previous year. At the time, a senior representative of the CBvS estimated that the Bank still only purchased 25% of the total amount of gold produced (estimate for 1997-1998; Heemskerk, 2000). About two-thirds of gold was thought to be smuggled to French Guiana (Stichting Planbureau Suriname, 2008). One reason for selling gold abroad may have been that in addition to the 1 percent royalty, ASGM had to pay five percent of the value of the gold to the CBvS for insurance, transportation, and refining. An additional explanation for the low gold purchases by the CBvS was the limited availability of foreign exchange. The National Planning Office (2008) comments that in 2001, gold purchases by the CBvS dropped with 23 percent due to the Bank's lack of available convertible currencies.

In these years before 2002, most jewellers bought their gold directly from the gold miners. Even though this practice was forbidden by law, there was no active prosecution of violators of the law. Gold was melted in the gold shops to remove impurities, including mercury. Between 1994 and 2002, the CBvS was

the only legitimate exporter of gold. The Royal Canadian Mint, a Canadian government gold institute, was the agent for these sales.

In 2002, the market was partially liberated. Five gold buying agents received an export license, allowing them to sell their gold abroad. In addition, in 2003, the regulation that buying agents had to sell to the Central Bank was abolished (Heemskerk, 2010).

Figure 18. Gold purchases registered by the Central Bank of Suriname



Sources: Heemskerk 2010 and CBvS 2015

4.1.2 Gold marketing chain at present

Nowadays, six firms in Suriname have a gold buying and export license, and three other firms only have a gold buying license (Ms. Vaseur, interim director Currency Committee, pers. com. 05/05/16). Those without an export license sell to one of the licensed exporters. The gold buyers purify the gold that is offered for sale using a burner, oven and/or borax. They determine the purity of the gold with the water density test[8]. After purification, testing and weighing, the buying house pays the gold miner the actual spot price, compensated for the purity, minus 6 - 7%[9]. The reduction is composed of 2.75% royalty to the Central Bank of Suriname, license duty and statistical fee (*consent en statistiekrecht*; 1.5%), fee to Kaloti

[8] Suriname gold they are offered for sale is on average 92% pure gold and 8% impurities (other metals etc). However, a consulted gold buyer reported that gold from specific locations in Brokopondo can be up to 98% pure.
[9] The three consulted buying houses reported deducting 6%; 6.25%; and 7% to cover expenses

(0.25%), expenses (processing, transportation, administration; ~1.5%), and profit margin of the buying firm (~0.5%):

Gold price received by ASGM = (LBMA spot price * % purity) – 2.75% royalty – 1.5% other fees to government – o.25% to Kaloti – 0.5% buyer's profit margin

On May 18, 2016, prices of gold at the various gold buying houses ranged from USD 36.94/g. gold to USD 37.45/g. gold. At that day, the London Bullion Market Association (LBMA) Gold Price was USD 40.86/g. gold (USD 1270.90 per troy ounce).

In contrast to the situation in French Guiana, Suriname gold buying houses do not request identification from the seller of gold. They may ask where the gold comes from, but only as in indication of purity, not to determine whether the mining location is a legal concession. A representative of one of the gold buying houses explained that in theory, identification is demanded in the case of sales over USD15000,-. However, since they work with many regular customers, they do not always ask for identification in the case of these high-end transactions. Buying houses do report to the Hotline Unusual Transactions (*Meldpunt Ongebruikelijke Transacties* MOT).

Virtually all gold from the Suriname ASGM sector is –most likely- sold to legal gold buyers. A share of the gold that is earned by ASGM is used as payment for goods and services in the mining areas, and hence circulates internally. ASGM also may sell some gold in the mining areas to obtain cash, for example to buy a plane ticket to the city. There are also international money transfer systems in place where, for example, a Brazilian gold miner pays in gold to a representative in the mining area, who subsequently arranges for the equivalent sum of money to be deposited in a bank account anywhere in Brazil. This system seems to be relatively more common in French Guiana, where ASGM cannot easily travel to urban areas for fear of being deported.

Informal buyers sell their gold somewhere, just like shop owners, transport providers, sex workers and other service providers who get paid in gold. For those working in Suriname, the most obvious choice would be to sell to a legal gold buyer in Paramaribo. After all, given the good price paid for gold in Suriname, and the fact that payments can be made in various currencies (SRD, USD or EURO), there is little reason for someone wanting to sell gold to smuggle it abroad. It is possible that there are underground gold buying houses, but we have not heard about them. Local jewelers are allowed to buy gold before it is exported, but most gold is exported.

It is very likely that a share of gold mined in Guyana and French Guiana is sold in Suriname. In 2016, the Guyana Minister of Natural Resources disclosed that an estimated 15,000 ounces of gold were slipping across the borders every month[10]. The Minister tentatively put the smuggled figures between 50 and 60 percent of total production, and an annual loss in taxes and royalties of USD 40 million. Suriname was mentioned as one of the destinations where Guyanese gold is smuggled to. The much higher royalties and

[10] Kaieteur News Online January 7, 2016. URL: http://www.kaieteurnewsonline.com/2016/01/07/fbi-shares-info-on-gold-smugglers/

taxes in Guyana (8%, versus 4.25% in Suriname) make selling gold in Suriname much more lucrative. A delegation from Guyana has also visited the Central Bank of Suriname to request assistance in halting gold smuggling from Guyana (Wolfram, Manager Corporate Affairs CBvS, pers. com. 20/05/16).

In French Guiana, gold taxes are low. In 2015, gold mining operations had to pay, depending on the type of enterprise ("small and medium enterprises" or "other enterprises"), 1 to 2 % of the annual medium gold price per Kg on the London Bullion Market in 2014[11]. However, there are other reasons for people working illegally in French gold fields (an estimated 10,000 persons) to sell their gold abroad. In the first place, French gold buying houses ask for identification and proof that the gold was mined legally. Even though there may be ways around this by selling to an intermediary, it makes selling gold more difficult. Secondly*, garimpeiros* (Brazilian gold miners) without legal residency status have much more freedom of movement in Suriname. So even though they work in French Guyana, they may live, rest, and have their family in Suriname. And, third, many ASGM who work in French Guyana buy fuel and other supplies in Suriname, where prices are lower. As a result, it is likely that a significant share of illegally mined gold from French Guiana –particularly near the border- is sold in Suriname. In Suriname, this gold becomes part of the legal economy when it is sold to a legal gold buyer.

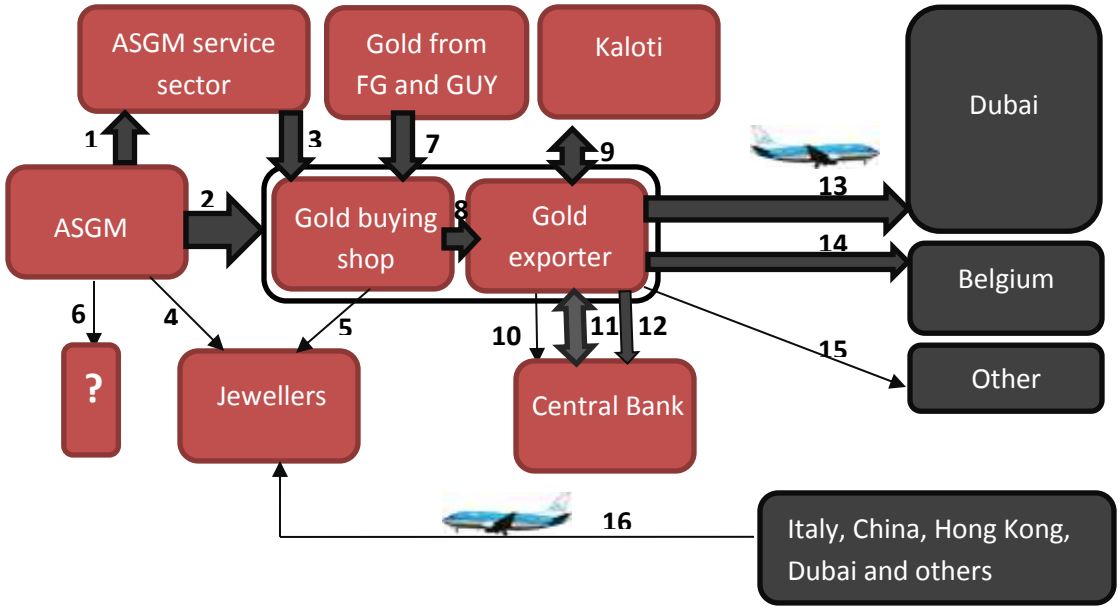
In 2015, the government of Suriname obliged gold exporters to calibrate and weigh their gold at the Kaloti Suriname Mint house prior to export. Kaloti returns the gold to the exporter with a letter stating how much gold will be exported, and how much royalty must be paid to the government. At the moment, Kaloti Suriname does not purify the gold that is offered for calibration any further. If, however, the demand for such a service grows, Kaloti Suriname will be able to fabricate coins and bullions.

One of the gold exporters filed and won a court case against this procedure; its representative stated that he found the fees to high[12] and did not agree with the Kaloti procedures. This firm exports its gold to Belgium (Antwerp), where it is refined. An appeal process will soon be examined by the Supreme Court. For the time being, about 80 percent of ASGM gold sold in Suriname goes to Kaloti for purification. The remaining ~20 percent of gold goes directly to the CBvS where it is weighted and samples are taken for analysis in the CBvS gold lab[13]. The royalty is determined on the basis of these samples.

Gold from the multinational mining firms Rosebel Gold Mines NV (Iam Gold) and Surgold (Newmont) does not go through Kaloti.

[11] See https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000031184390&categorieLien=id
[12] At the CBvS, they only pay 30 USD per shipment.
[13] The difference between the process at Kaloti and the process at the CBvS is that at Kaloti, the entire shipment of gold from the buyer is melted and calibrated, whereas the CBvS chips off a small piece of a sample of gold bars for testing.

Figure 19. Gold marketing chain in Suriname



1. ASGM use part of the gold they earn for goods and services in the mining areas
2-3 ASGM and ASGM service providers sell their gold to formal gold buyers
4-5 Both ASGM and legal gold buyers may sell small amounts of gold to jewellers
6. It is possible that small amounts of gold are sold to illegal gold buyers and/or smuggled abroad, but we have no proof or heard about destinations.
7. Gold from neighbouring Guyana, where the royalty on gold is 7%, and French Guiana, where selling gold is more difficult for unlicensed ASGM, is smuggled to Suriname and sold to one of the gold buyers.
8. Most gold buyers also have an export license, but those who do not sell to an exporter. One licensed buyer/ exporter has no actual buying houses, and relies on one of the gold buyer without an export license for its exports
9. Gold from exporters (but 1) is calibrated and weighted at Kaloti, against a 0.4% fee. Kaloti returns the gold with a letter stating its weight and the royalty to be paid to the GoS.
10. Gold exporters pay 2.75% royalty to CBvS, in USD.
11. About 20% of gold sold in Suriname does not go Kaloti, but is sampled and weighted at the CBvS, where the royalty is determined.
12. CBvS has a right to buy 5% of export gold at spot price, paid in SRD against the valid CBvS exchange rate
13. Most Suriname gold is exported to Dubai

14-15. One gold exporter exclusively sells to Belgium, and smaller amounts go to other countries

16. Jewellery sold in Suriname is for the largest share imported from various countries, and rarely made of Suriname

The gold export license states that the CBvS has an option to buy 5% of the to-be-exported gold. Since April 2016, the CBvS enforces this regulation and buys gold against the LBMA spot price[14] in Suriname dollars (SRD). The reason for this arrangement is the diminished gold reserve, which the current President of the CBvS is trying to restore (Mr. Wolfram, Manager Corporate Affairs, Central Bank of Suriname, pers. com. 20/05/16). A representative of one of the larger gold export firms estimated that of their most recent shipment, 20 percent of their gold was sold to the CBvS and the remaining 80 percent was exported. Another gold exporter reported selling approximately 5 percent of each shipment to the CBvS. It is unclear whether this regulation also applies to the multinational mining firms.

One of the gold buyers also imports gold; coins of 4,8,10 or 20 g. or small bullion sticks of 1 troy ounce. In total, about 10 to 20 kg of gold is imported annually, from any refinery or bullion bank[15]. Golden jewelry sold in Suriname is mostly imported from abroad; only a small share of pieces in local jewelry shops was produced locally.

Consulted representatives of gold buying houses reported that they had no way of keeping mercury free gold separate from other gold. All gold goes into the same melting pot. Two gold buying firms indicated that they do make an effort to promote mercury free mining. The director of Suriname Natural Stone indicated that the firm searches for funding to help ASGM buy equipment for mercury free mining. The director of Amazon gold reported that the firm seeks to be a Socially Responsible Business (SRB) and in this context works with Conservation International to promote mercury free mining. Their intention is to launch an awareness campaign with the emphasis of increasing profits with reduced mercury use. The director of Kaloti Suriname indicated that if there is a demand for melting and calibrating smaller quantities of (Hg-free) gold, Kaloti Suriname could set up such facilities.

Apart from the royalties, which are collected at the point of sale, very few ASGM pay any additional taxes. Tax department staff has occasionally visited the gold mining areas but the department lacks the staff and resources to consistently collect taxes and execute control on tax payments from people in the interior. In 2009, the tax department collected no more than 118,728 SRD (~ USD 4,000) in tax payments from registered ASGM gold producers; “sadly little” in the words of its director. In 2012, the tax department announced a large intervention to collect tax from ASGM, and sent out hundreds of tax assessment forms to (registered) mine operators. In 2014, the Tax Department in collaboration with OGS seized the equipment of skalian (pontoon) operators on the Marowijne River who had not paid taxes. Such activities, however, are incidental and tax collection from gold operations is intermittent and based on grossly underestimated self-assessments.

[14] This Price is determined twice daily, for Suriname at 6AM and 11 PM.

[15] This gold is not bought from Kaloti in Suriname because at the time of this report, Kaloti was only purifying gold, but not (yet) fabricating coins and bullions.

5.2 Mercury flows

5.2.1 Mercury supply chain

Suriname does not produce chemical mercury, but mercury is found as a by-product from the mining of minerals such as bauxite and gold. Bauxite mining firm Suralco, a daughter firm of the US mining giant ALCOA, collected mercury that was liberated during the mining process. According to the trade statistics database of the United Nations, Suriname exported 1.300 Kg mercury (USD 4,000) to the Netherlands in 2010, and 102 Kg (USD 850) of mercury to the United States in 2011[16]. No other mercury exports have been reported for subsequent years (UN Comtrade 2016). There are accounts that gold miners used to – illicitly- buy mercury from employees in the bauxite industry, but it is difficult to verify these accounts and establish a quantity.

When ASGM sell their gold to a gold buyer, the buyer burns the gold again. One would expect that left-over mercury evaporates in this process, and is captured in the gold shop's retorts or fume hoods. A consulted gold buyer, however, reported that they find "no visible mercury" in their filters or elsewhere during the purification process.

It can be safely assumed that most mercury used in the ASGM sector enters Suriname from abroad. In January 2006, the Ministry of Trade and Industry ruled that a license is required to import mercury. Since that date, no licenses for mercury import have been issued[17]. This implies that all mercury entering Suriname from abroad enters the country illegally (Duijves and Heemskerk, 2014). Judging from newspaper articles about the arrest of smugglers, one foreign source of mercury is Guyana. Furthermore, a recent EU report on gold and mercury in the Guiana shield also points at the EU as a possible source of mercury smuggled to Suriname (Veening et al., 2015).

Guyana imports virtually all mercury that is used domestically or taken abroad. A recent WWF report indicates that over the period 2008–2013, mercury in Guyana was sourced from 10 countries. Previous major suppliers, including Spain and the USA, were superseded in 2013 by China, which provided almost 60 tons of mercury in 2013 (approximately 75% of the total imported). This change was likely due to export bans from the other countries (Legg et al. 2015). Other sources point at Venezuela and Brazil, from where garimpeiros or persons in the mining service sector bring mercury in small quantities for the ASGM sector (Kaieteur News, 2013)[18].

Once mercury has entered Suriname, it is sold at locations in Paramaribo where ASGM get together, such as in "Little Belem"[19]. Mercury is sold in shops and in the streets by cab drivers and mobile vendors. In

[16] UN COMTRADE databass: URL:
http://comtrade.un.org/db/dqBasicQueryResults.aspx?cc=280540&px=H3&r=740&so=7

[17] Also the UN Comtrade database does not report any mercury imports in the past decade.

[18] http://www.kaieteurnewsonline.com/2013/08/04/govt-moves-to-probe-how-mercury-enters-country/

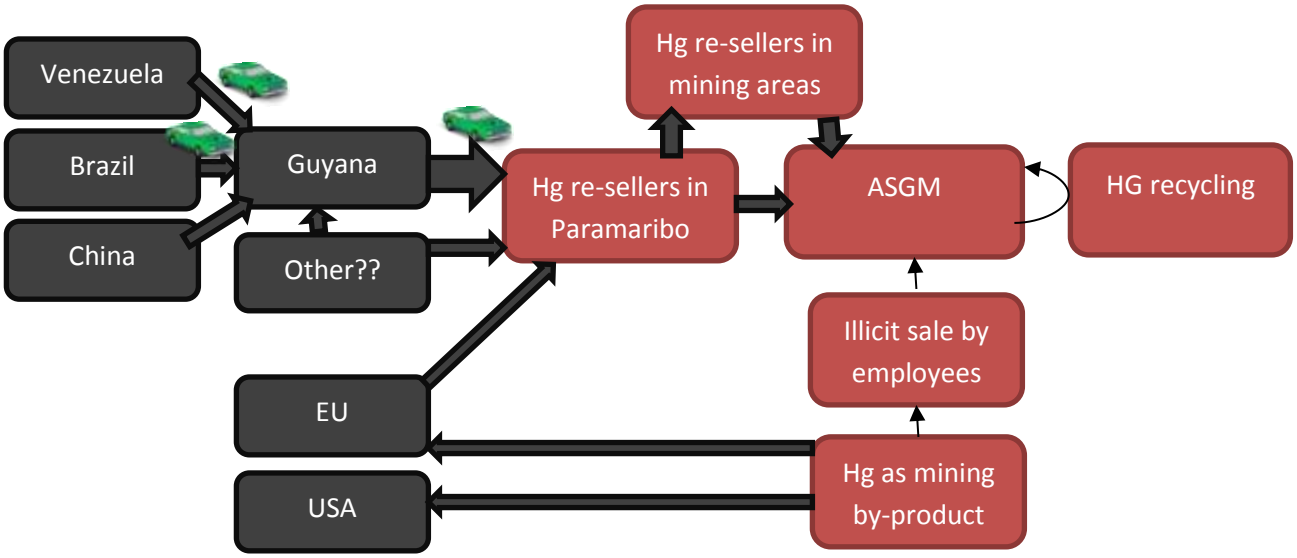
[19] Neighbourhood where many Brazilians garimpeiros stay, hang out and buy supplies.

May 2016, mercury sold for USD 100-110/Kg in Paramaribo. Some persons buy mercury for own use, while others buy it for resale in the mining areas. In a 2014 survey among ASGM, we found that about 30 percent of surveyed gold miners had bought mercury in the mining areas (Duijves and Heemskerk, 2014).

ASGM miners recycle mercury when they squeeze the amalgam through a cloth after its first collection. During this process, the mercury-gold amalgam is secured in the cloth and excess mercury is collected for re-use. When burning the amalgam, it is common to cover the gold pam with large leaves. Evaporated mercury sticks to the leaves, which are subsequently washed in water to collect the mercury. The percentage of mercury present in the amalgam that is recovered during the burn using this leaf technique is unknown, but is likely very low. The use of retorts is uncommon. Nevertheless, it is likely that through the artisanal processes described above, a substantial share of mercury applied to the ore is used more than once.

Section 8 provides our estimate of mercury use in Suriname. Measurements of mercury in the natural environment and people in Suriname are described in Annex A.

Figure 20. Mercury marketing chain



6 STAKEHOLDERS

Stakeholder	Dutch name and abbreviation	Role/ tasks/responsibilities
Government		
Commission Regulation of the Gold Sector	Comissie Ordening Goudsector (OGS)	Development of ASGM policy; Law enforcement in ASGM areas, including evictions of ASGM; Conflict resolution in ASGM areas, incl. conflicts between communities and ASGM, and conflicts between ASGM and mining title holders; Management of the ASGM Reserve areas; Registration and documentation of ASGM.
Ministry of Natural Resources	Ministrie van Natuurlijke Hulpbronnen (NH)	Development and control of mining policies and regulations; granting reconnaissance, exploration, exploitation or small-scale mining rights to both small- and large-scale mining firms; Development, signing, and implementation of mineral agreements (*delfstoffenovereenkomst*) with the multinational mining companies.
Geology and Mining Department	Geologische Mijnbouwkundige Dienst (GMD)	The GMD falls under the Ministry of NH and has formally among its tasks geological mapping, inventory of Suriname's mineral reserves, advising the Minister of NH about mining rights and the control thereof. The GMD also advises third parties about mining concession applications. Nowadays in practice, tasks of the GMD with regard to gold mining are mostly the control and preparation of concession applications for the Ministry of Natural Resources (Mr. Paansa, GMD, pers. com. 11 Feb 2015). The OGS took over control on actual gold mining activities in the field.
Central Bank of Suriname	Centrale Bank van Suriname, CBvS	The CBvS registers gold that is legally exported from Suriname. Its gold lab also samples and weighs gold of the one gold buyer who does not work with Kaloti. Royalty on gold (2.75%) is paid to the CBvS.
Medical Bureau of the Dept. of Labour Inspection, Ministry of Labour	Medisch Bureau, Arbeidsinspectie, Ministerie van Arbeid	As part of its task to safeguard safety, wellbeing and health on the work spot, the Medical Bureau controls gold buying agents on compliance with legal requirements with regard to Hg exposure at work. Samples are taken, and in the case of violations of the law, a complaint report is written and the perpetrator is trialed in rapid court (since 2015).
The Central Lab of the Bureau Public Health care, Ministry of Health	Centraal Lab (CL), Bureau Openbare Gezondheidszorg, BOG	The BOG Central Lab measures the presence of mercury various kinds of samples, including water, fish, and sediments. Its focus, however, is on human exposure; hair, blood, urine. The lab is ISO certified and in the process of accreditation for medical analysis.

Environmental office, Cabinet of the President	Afdeling Milieu, Kabinet van de President	The Environmental Office within the Cabinet of the President is the national coordination point for environmental issues in Suriname. Environmental policy is developed by the Environmental Office in close collaboration with NIMOS (see below)
National Institute for Environment and Development in Suriname.	Nationaal Instituut voor Milieu en Ontwikkeling in Suriname, NIMOS	In collaboration with the Environmental Office of the Cabinet of the President, NIMOS is responsible for the development of environmental policy. NIMOS also serves as the practical working arm for the Environmental Office (i.e. performing field inspections).
Currency Commission	Deviezen-commissie	This office has as its task to implement and control currency traffic regulations[20] under auspices of the President of Suriname, who is responsible for the national currency policy. The Currency Committee also allocates permits for the use and possession of foreign currency and gold in Suriname, and extends licenses to gold buyers and exporters.
Ministry of Trade and Industry Economic Control Service	Economische Controle Dienst, ECD	The ECD executes field inspections when the Ministry receives a complaint about unlicensed gold buying. The ECD is legally authorized to undertake action, in collaboration with the police
The Department of Import/Export and Currency control, at the Ministry of Trade and Industry	Import/Export en deviezencontrole, IUD. Min. Handel en Industrie	Controls and extends the gold export license on the basis of a delegated responsibility.
District authorities		
District government, headed by the District Commissioner	Districtsbestuur, geleid door de District Commissaris (DC)	The DC is the representative of the national government in the districts. In addition to the DC, the district government consists of **District Secretaries** and resort[21] supervisors named ***Bestuursopzichter (BO*)**. The DC and his staff constitute the practical working arm of the **Ministry of Regional Development (*Regionale Ontwikkeling*)** in the interior districts. By law, the Ministry of NH has to ask for the DC's advice with regard to the extension of concession applications in his/her region. In practice, the DC is often not consulted.

[20] The Currency Regulation (*Deviezenregeling*).

[21] A resort is an administrative subdivision of a district

Gold mining title holders		
International firms; Iam Gold and Newmont	Resp. Rosebel Gold Mines N.v. (RGM) and Surgold	Canadian mining firm IAMGOLD operates the RGM project in Brokopondo district The Suriname government has a 5 percent stake in the Rosebel joint-venture. The Suriname Gold Company LLC ("Surgold")[22] mine at Merian is scheduled to go in production in August 2016. The State of Suriname, represented by Staatsolie Maatschappij Suriname N.V. ("Staatsolie"), has a fully-funded, 25 percent equity ownership stake in the Merian Gold Project. The locations of these multinational firms are indicated in Figure 21.
State mining company Grassalco N.V.	Grassalco	In November 2014, Grassalco), took a medium-scale gold mining plant in production at its gold mining concession at Maripaston (Figure 21), where it is processing the mine tailings (bakasanti) from ASGM operations that preciously worked on the concession, which still contain quite some gold. In the meantime Grassalco searches for unexploited ore deposits for a second stage. Grassalco works with gravimetric ore concentration without the use of mercury. The chemical borax is used in the final refining stage.
Other mining title holders	Est. 30-40 gold mining rights owners	Various, mostly urban Suriname residents, possess exploration, exploitation and small-scale gold mining rights. A copy of the map with mining titles could not be obtained. In theory, it is possible to view the concession map at the Ministry of NH, but to this date permission has not been granted to the consultant.
Traditional rights holders	Maroon and Indigenous comm. members	Different Indigenous and Maroon tribal groups, clans, and extended families claim specified areas of the interior as their ancestral lands. When ASGM takes place on their lands, a (formal or self-appointed) representative of the land claim holder will request concession fee payment from the gold miners. These payments may also take place in kind, for example, fuel for the community generator.
Education institutes and academic researchers		
University of Suriname; Technical college	Anton de Kom (ADEK**)** Universiteit van Suriname; Natuurtechnisch Instituut (NATIN)	Both ADEK and NATIN offer a study in mining (respectively BSc or non-degree mining diploma)
School of Mining and Mineral Processing	SMMP	In 2011, the then newly established School of Mining and Mineral Processing (SMMP) received a USD 244.440 grant from the (SEMIF) to develop a "Satellite field station for capacity building

[22] Surgold is a limited liability company fully owned by Newmont Mining Corporation.

		in the mining sector". The grant was used to construct a building at Snesi Kondre and buy equipment, including i-concentrators (i-con) and shaking tables. By the end of February 2012, the SMMP was supposed to start a 6-month bachelor level course on mercury-free gold mining but this never happened. The SMMP still exists in name but no activities are executed. The SMMP is headed by Mr. Courtar from the Medial Bureau of the Ministry of Labor.
School of Geology and Mining Technology	SGMT, at the University of Applied Sciences and Technology (UNASAT)	In 2015, the SGMT at UNASAT started offering a 6-month bachelor level course on mercury-free gold mining technologies for graduates of the secondary technical school NATIN and bachelor students of mining – much like the SMMP previously. The course teaches competencies to work Hg-free in exploration, concentration and purification phases of gold mining. Field training for students takes place in Brokopondo district within OGS installed mining reserves (Km. 58 and Km. 68 of the Atjoni road) and in the Paamaka gold mining reserve near Snesi Kondre/Merian), which the OGS allocated to UNASAT. UNASAT/SGMT works with the i-concentrator (i-con) and a shaking table. Part of its equipment was obtained through a loan agreement with the SMMP. The school receives –partly in-kind- support from Surgold[23]. Two UNASAT/SGMT graduates were involved in the testing of an Hg-free mining plant (i-con) on the mining concession of Surgold. The graduates also trained and guided one team of gold miners in a pilot project to promote Hg-free mining among ASGM.
Mr. Wip, senior lecturer at the ADEK Dept. of Physics	Dhr. Wip, docent Natuurkunde, ADEK	Mr. Wip at the ADEK Department of Physics has a special interest in the measurement of atmospheric mercury, as well as measurement of mercury in plants and food crops. Among others, he has alerted policy makers and the national public to the high atmospheric Hg levels around gold buying houses in residential neighbourhoods.
Players in the gold marketing chain		
Gold Buyers	Goudopkopers	Nine firms received a gold buying license. Virtually all gold buying offices are located in Paramaribo, with the exception of offices in Albina and Antonio do Brinco. Gold offered for sale to the buyer is burned to remove impurities (mostly residual mercury) and to determine fineness. Buyers pay the world market price of gold, minus 6-7 percent for royalty (2.75%) and overhead costs.

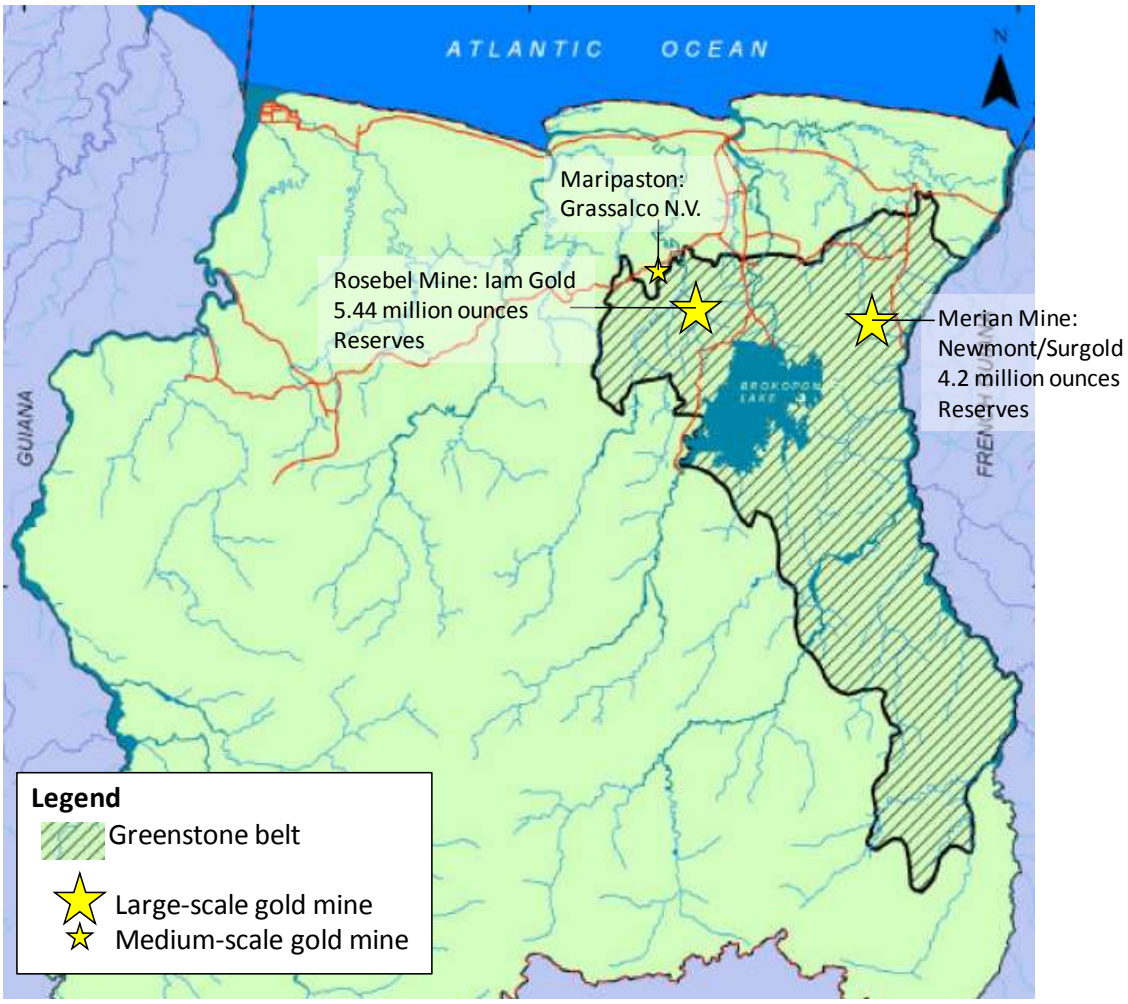
[23] Surgold (Suriname Gold Company LLC) is owned by Newmont Mining Corporation ("Newmont").

Gold exporters		Since 2002, the CBvS has delegated its task as gold exporter to private companies. Of the nine firms with a gold buying license, six also have an export license. The other three firms sell the gold they purchase to one of the legal exporters. One of the exporters does not have any buying houses, but has an agreement with one of the gold buyers to buy all its gold.
Kaloti Suriname Mint House		Since August 2015, gold exporters are obliged to clean and calibrate gold at the Kaloti Suriname Mint House prior to export. Based on the results, Kaloti provides a proof of purity and royalty, which is used by the Exporter to pay tax. One exporter does not work with Kaloti but has its gold calibrated by the CBvS to determine the amount of royalty payment.
Sellers of mining equipment for mercury free mining		
CKC machinehandel Surmac N.V.	Surmac (a subsidiary of Kersten N.V.)	Surmac is the Suriname distributor of the i-concentrator (i-con), which is fabricated in Canada. Surmac collaborates with the educational institute UNASAT, whereby UNASAT students assist with installation and provide training to new i-con users. The consulted Surmac representative could not tell how many i-cons had been sold or were currently in use in the field, nor whether the unit used in the Surgold Hg-free mining project was the only one working now[24].
Global Mining Solutions		Equipment from the mining equipment vendor Global mining Solutions is distributed in Suriname by mechanical engineer Mr. Landsdorf. This equipment includes shaking tables and oscillating sluices. One of the smaller shaking tables was placed behind the i-con in the Surgold Hg-free mining project (rented by Surgold). Lansdorp plans to install a pilot plant at Bewojo, Brokopondo district[25].

[24] R. Grens, Surmac representative. Pers. com. 03/05/16.

[25] J. Lansdorf, distributor Global Mining Solutions. Pers. com. 16/05/16

Figure 21. Location of large-scale mining forms and state mining firm Grassalco in Suriname



Source: Social Solutions 2015

7 LEGAL FRAMEWORK

7.1 The 1986 mining decree

The main legislation governing the exploration and exploitation of mineral resources is the Mining Decree[26] of 1986, which authorizes the Geological and Mining Department (GMD) to grant mining rights and other licenses, and regulate, inspect, and monitor the mining sector. The GMD is a department of the Ministry of Natural Resources. Under the Mining Decree, minerals are classified in five categories: bauxite; radioactive minerals; hydrocarbons; other minerals, excluding building materials; and building materials. Gold is categorized under the category "other minerals". The Mining Decree regulates the procedures for granting mining rights, and their scope and duration.

The mining law distinguishes rights of reconnaissance (max. 200,000 ha), exploration (max.40,000 ha.), and exploitation (max.10,000 ha) (Table 2). For large-scale gold mining, these different rights have to be applied for separately. The maximum duration for these rights is, respectively, 2, 7, and 25 years, with the option to renew. A fourth mining title recognized by the mining law is a small-scale mining right, which may be requested for areas of no more than 200 ha. The small-scale mining title includes rights of reconnaissance, exploration, and exploitation in one title and is valid for a maximum of 2 years, with the option to renew. The Mining Decree defines small-scale gold mining as "the reconnaissance, exploration, and exploitation of a mineral deposit whose nature, mode of occurrence, and quantity allows for economic mining by simple means and techniques".

Table 6. Suriname mining titles relevant to gold mining

Title	Max. area	Validity	Options for extension
Reconnaissance (*Verkenning*)	200,000 ha	Max. 2 years	One extension, for a period of 1 year
Exploration (*Exploratie*)	40,000 ha	Max. 3 years	Two extensions, for 2-year periods
Exploitation (*Exploitatie*)	10,000 ha	Max. 25 years	Unspecified, needs to be requested 2 years prior to expiration
Small-scale mining (*Kleinmijnbouw*)	200 ha	Max 2 years	Unlimited extensions, for 2-year periods

Source: 1986 Mining Decree

The mining rights of the multinational mining firms have been specified in the Gross Rosebel Act (between IAMGOLD/RGM operations and the Government of Suriname) and the Mineral Agreement between the Government of Suriname and Newmont/Surgold.

[26] DECREET van 8 mei 1986, houdende algemene regelen omtrent de opsporing en ontginning van delfstoffen (Decreet Mijnbouw) (S.B. 1986 no. 28), S.B. 1997 no. 44.

The section on small-scale mining in the Mining Decree[27] (Ch. VII) does not specify any regulations with regard to environmental and human health. For the mining sector in general, the Decree stipulates that mining must be carried out with "consideration for valid norms in terms of safety and health of employees specifically and of the community in general, as well as norms for the protection of ecosystems" but it does not define these norms. The 1986 Mining Decree also stipulates in Article 16.1 that upon terminating a mining right, "the right holder shall, to the approval of the Minister, execute all necessary measures in the interest of public safety […] and protection of the environment". When the right holder fails to execute such measures, the State has the right to execute such measures on cost of the right holder. To our knowledge, the State has never applied this Article. Mercury is not mentioned in this law.

For the past couple of years, Parliament has been working on an amendment to the 1986 Mining Decree and a new Gold Act. These two laws focus on the regulation of the ASGM sector and include the following topics: taxation of small-scale gold miners, adjustments in percentages of royalties, and gold mining on water (Central Bank of Suriname, 2014). July 2-16, the GoS installed a Commission Revision Mining Law and Mine Development Agreement (*Commissie Herziening Mijnbouwwet en Mijnontwikkelingsovereenkomst*), which has among its tasks to revise the 1986 Mining Decree. It is unclear when the revised Mining Decree will be finalized, approved, and come into force.

7.2 Mining titles and permits

The Suriname 1986 Mining Decree stipulates that:

> "No one is permitted to conduct mining activities and activities related to mining unless they comply with lawful regulations related to mining. These activities can be conducted only after rights to do so have been granted by the competent authority…" (Art. 2.6)

The competent authority is the Minister of Natural resources (1986 Mining Decree, Art. 6)

By law, the holder of a mining right must have an office in Suriname and in case the rights holder is a natural person, this person needs to be a legal resident of Suriname and in the capacity to exercise rights (Art. 8). Small-scale mining rights can *only* be issued to natural persons who are legal residents of Suriname (Art. 36.4). Hence, in theory, any legal resident of Suriname can apply for, and be issued, a mining concession. In practice, however, most concessions are in the hands of the urban political and economic elite -even though *garimpeiros* and Maroons dominate the work force in the small-scale gold mining sector.

To gain and maintain a small-scale mining title the concession holder has to comply with a number of administrative, financial, and other obligations, depending on the kind of concession. In practice, however, neither the government nor the concession holders strictly comply with the legal rules. A large share of the concessions should have been withdrawn simply because their time, as defined in the Mining

[27] DECREET van 8 mei 1986, houdende algemene regelen omtrent de opsporing en ontginning van delfstoffen (Decreet Mijnbouw) (S.B. 1986 no. 28), S.B. 1997 no. 44.

Code, has expired. Secondly, only a few concessionaries comply with the reporting and financial requirements. Among those who do, the quality of the reports that are submitted is often questionable.

Other much ignored regulations include the prohibition to engage in commercial production on an exploration concession; the prohibition to sublet a small-scale gold mining concession; and the obligation to file for permission prior to subletting a large-scale mining concession. Concessionaries are seldom corrected and concessions are not withdrawn for different reasons. These reasons include the financial power and political alliances of some concessionaries, and a lack of capacity and funds in the Geology and Mining Department (Heemskerk and Duijves, 2013). Another shortcoming of the current Mining Code is that it fails to protect the customary rights of tribal peoples in the interior.

Information with regard to issued concessions is not public. A new law on Transparency of Governance (*Openbaarheid van Bestuur*) was submitted to the Council of Ministers in 2013, but has not yet been approved.

7.3 Laws and regulations with regard to mercury

In the government regulation Decision Negative List (*Besluit Negatieve Lijst* 2003; S.B. 2003 no. 74), which forms part of the law on the transportation of goods (*Wet Goederenverkeer*; S.B. 2003 no. 58), mercury is listed with the items for which an import license is required. Other than this regulation, there are no legal instruments that specifically mention mercury (F. Hausil, Legal expert at NIMOS, pers. com. 30/06/2014).

The Suriname legal framework contains no regulations about the sale of mercury. The criminal code dictates that it is punishable to "sell, offer for sale, deliver or hand out goods, knowing that the[se goods] are harmful to life or health, while omitting to mention their harmful character..." (*Wetboek van Strafrecht*, Art. 226). The criminal code also stipulates that it is unlawful to be responsible for "the sale, delivery or handing out of goods that are harmful for life or health, without the buyer or recipient being aware of the harmful character …" (*Wetboek van Strafrecht*, Art. 226) (F. Hausil, Legal expert at NIMOS, pers. com. 20/10/2014). From the above it appears that someone who informally sells mercury to a gold miner on a street corner, and who tells the buyer that this mercury is dangerous, does not commit an illegal act. Also the gold miner who buys mercury behaves within the boundaries of the law.

The labour law states that employees may not be exposed to "harmful gasses and fumes". The Occupational Accidents Regulation of 1947 (*Ongevallenregeling*)[28] names in Art. 24-25 under illnesses: "diseases caused by mercury or substances containing mercury, when these reveal themselves in employees in firms working with mercury or substances containing mercury". In the case of such illness the employee must be compensated, unless this illness can be blamed on his or her misconduct.

[28] Ongevallenregeling. G.B. 1947 no. 45. WET van 10 September 1947, houdende vaststelling van de verplichting van de werkgever tot en van de aanspraken van de in bepaalde bedrijven door enig ongeval of enige beroepsziekte getroffen werknemer op schadeloosstelling (G.B. 1947 no. 45), gelijk zij luidt na de daarin aangebrachte wijzigingen bij G.B. 1949 no. 90, G.B. 1950 no. 62, S.B. 1975 no. 164d, S.B. 1980 no. 116, S.B. 1983 no. 8, S.B. 2001 no. 66.

According to Mr. Courtar, head of the medical bureau of the Ministry of Labour, the Ministry works with the norms of the National Institute for Occupational Safety and Health (NIOSH) of the US Center for Disease Control and Prevention (CDC) (J. Courtar, pers. com. 12/05/16). The Ministry of Labour maintains a database with all gold buying shops and executes control. Since 2011, all legal gold buying shops are obliged to use a wet scrubber to capture mercury vapour and since 2015, gold shops need to have two wet scrubbers. The Ministry takes sample measurements inside the shops and in the case of a violation of the norm, the gold shop owner is brought to court (since 2015; J. Courtar, pers. com. 12/05/16)

Suriname does not have an umbrella Environmental Law. Environmental regulation is fragmented and specified per (economic or public) sector. A draft environmental law[29] was presented to the Council of Ministers in 2002, but has never been adopted. A draft State Decree (Staatsbesluit) to regulate mercury is also awaiting approval by the Council of Ministers (M. Riedewald, sub-director Environment, Ministry of ATM, pers. com. July 30, 2014).

7.4 Laws and regulations with relevance for the gold marketing chain

7.4.1 Gold processing

The following legislation applies to the different stages of gold processing:

- The Mining Decree;
- The Currency Regulation (Deviezen Regeling) and the Resolution on rules regarding extraction, processing and the transport of gold in regards to the Mineral Act;
- The Nuisance Act (Hinderwet 1929);

The **Mining Decree** (art. 34) stipulates that the holder of an exploitation right is entitled to process, transport and market the gold that he has mined within his concession (art. 34a). Regulations for small-scale mining title holders do not say anything about the processing of minerals.

The **Currency Regulation** stipulates that the import and export of gold are prohibited other than with a permit of the Currency Committee (art. 17). The **Resolution on rules regarding extraction, processing and the transport of gold**[30] rules that it is forbidden to process gold by melting, refining or alloying (Art. 2). Only the Central Bank of Suriname and gold miners in the field are allowed by law. It is not stated in this Resolution if the term 'gold miners' refers to all gold miners, both large and small-scale.

[29] The "Framework Law Environment" (*raamwet Milieu*) and the "Law Environmental Authority" (*Wet Milieu Autoriteit*)

[30] 48 Resolution on rules regarding extraction, processing and the transport of gold in regards to the Mineral Act; G.B.
1947 no. 139, last amended in S.B. 1959 no. 35.

The **Nuisance Act**[31] poses restrictions on the environmental impact, including noise, of firms. This law is not very specific and does not explicitly regulate mercury use or the emission of mercury vapours.

7.4.2 Gold trade

Gold trade is legally regulated through:

- General Orders 1 and 5 of the Currency Committee[32];
- The State Decree regarding the mailing of gold abroad through parcel post;
- The Bank Act.

Two **General Orders** (Algemene Beschikkingen) **from the Currency Committee** (Deviezen Commissie) are particularly relevant to gold trade. General Order no. 1 stipulates rules and regulations on the import, export, acquisition and sale of foreign currency and gold in Suriname. The Currency Regulation also stipulates that it is forbidden to possess and or acquire gold without a permit. General Order no. 5 allows gold buyers to sell raw gold for industrial and artistic purposes to third parties, without a special permit from the Currency Committee

The **State Order regarding the mailing of gold abroad through parcel post** describes the regulations that need to be followed when mailing gold by parcel post.

The **Bank Act** describes the tasks of the Central Bank of Suriname (CBvS) as national monetary authority. Among others, it licenses the CBvS to trade in precious metals, convert gold into coins and to test and refine gold. Other functions of the CBvS have been described above.

[31] S.B. 2001 no. 63. WET van 8 oktober 2001 tot nadere wijziging van de "Hinderwet" (G.B.1930 no.64, zoals laatstelijk gewijzigd bij G.B.1972 no.96).

[32] Published in the Governments Announcement paper (Gouvernements Advertentieblad, G.A.B.) of 1947 numbers 81 and 104.

8. INTRODUCTION TO ASGM INVENTORY ESTIMATES

ASGM inventory estimates aim to reduce uncertainty surrounding ASGM miner population, gold production, and mercury usage. Current inventory estimates are limited. Improving inventory estimates is key to understanding the sector, and allowing the development and implementation of projects aimed towards mercury reduction and improved practices. Producing accurate ASGM inventory estimates is difficult given the geographically widespread yet remote nature of ASGM sites, the diverse extraction and processing practices present, and the general informality sector. Various approaches may be used to estimate inventory unknowns, and cross checking data using multiple lines of evidence is essential to reducing error in inventory estimates. This section outlines existing inventory data, presents examples of cross-checks that may be used to verify existing data, discusses some field data gathered during 2 weeks of field visits conducted under this project, and offers some example inventory methods that may be further developed and applied to conduct more in depth ASGM inventory assessments in Suriname.

8.1 Existing ASGM Inventory Information

Understanding a country's ASGM miner population, gold production and mercury usage is important when developing technical and policy solutions that address the issues associated with the sector. The best constrained piece of currently available inventory information is an annual ASGM gold production estimate of 18.85 T/year from 2015, produced by the Central Bank of Suriname. This estimate is based on data from gold buying houses in Paramaribo. While this estimate is a good starting point, it does not take into account potential unreported cross border flows. Due to favourable selling conditions in Suriname as compared to neighbouring Guyana and French Guyana, it is likely that a more than an insignificant portion of this gold is produced in Guyana or French Guyana and enters Suriname, where it makes its way to Paramaribo's gold buying houses. However, the amount of gold entering Suriname across borders has not been quantified. Additionally, a large share (est. 60-70%) of the Surinamese ASGM work force is composed of Brazilian workers. Financial flows to Brazil are prevalent. While it is likely these workers sell their gold domestically within Suriname and send money back to Brazil, it is possible that some of the gold produced in Suriname flows out to Brazil to family members of Brazilian miners. Quantifying illegal cross border gold flows is extremely difficult, and would require a large amount of research and resources; however, simple back calculations to cross check the reported 18.85 T of production can be completed to verify the plausibility of this assumed Surinamese ASGM production.

Given the migratory nature of ASGM sites, where miners follow local booms and chase high ore grades, determining miner populations can be very difficult. The OGS has attempted to quantify miners through a registration system in which all miners are issued miner ID cards, which are required if they are to continue mining. As of June 2016 the OGS reported having distributed ~7000 cards; however, they acknowledge that this is not the true total number of miners, as many were unreached. The OGS suggest an estimated miner population of ~10,000 – 12,000 miners. A second miner population estimate was completed by C. Healy based on the distribution of ASGM sites (Healy 2009), suggesting 10,000-11,000 miners. Furthermore, Healy and Heemskerk (2005) estimated the presence of 800-1200 ASM operations

in Suriname, which would translate to 10,000-15,000 persons working in the ASGM sector, including the service economy.

The amount of mercury use and emissions in the country associated with ASGM operations is particularly poorly constrained. Legg et al. (2015) suggested that 28.5–57 tonnes of mercury may have been used in the Suriname ASGM sector in 2011; however, it is noted by the authors that these data are outdated and may no longer be accurate. None of the various groups interviewed from government or non-governmental organisations were able to produce any estimate of mercury emissions. The reasons cited were poor import controls as national data show zero recorded mercury import and the wide spread underground usage of mercury in the sector, including a degree of secrecy around the amount used by miners. An outcome of this scoping trip has been to determine a rough estimate of mercury use, as discussed below in 8.11.

8.2 Inventory data collected during this trip

As required for the development of inventory methodologies, the assessment team conducted initial scoping and site visits. Nine ASGM sites were visited and over 20 structured qualitative interviews were conducted with miners and mining groups to better understand processing workflows and to develop Suriname specific inventory methodologies. Conversation with gold miners was coupled with observations and some basic physical measurements. Useful information collected from the field can be applied to check existing inventory information and to develop initial Hg:Au ratios, and in turn initial mercury use estimates.

8.3 Throughput per system

Most miners had very little knowledge of the throughput per system. This is due to the large volumes of material proceed each day, and the haphazard approach taken to processing. Miners generally base their production on number of barrels of fuel consumed, rather than processing system ore throughput. Discussions with the executive director of a highly organised Small Scale Mining company using similar, but refined, processing workflows to those used in ASGM (spurting and suction hoses and sluices) suggested an average daily throughput for ASGM groups of ~100 T/d per system. This estimate uses an average daily production, and does not factor in downtime. For example, in a month an ASGM site would produce ~3,000 T of ore. However, site visits showed that at any given time only ~50% of systems were operational, and consulted ASGM groups reported that their systems may only be operational 15 days of the month. If total average daily production for the month is 100 T/d of material; it is likely that this material was produced in 15 days, doing 200 T/d operational. This range of 100-200 T/d seems reasonable, and will depend on type of ore, processing workflow, and the efficiency of the systems. These throughput estimates have been cross checked by conducting simple observations, physical measurements and calculations from a spurting/suction hose and sluice system observed in the field. The below calculations provide an example of the sorts of rudimentary field data based cross checks that can be applied to verify other lines of information.

Cross Check 1:

- Sluice length = 14 m
- Water velocity = ~1.25 m/s
- Sluice width = 0.8 m
- Water depth = 0.01 m
- Throughput rate = 0.8 m x 0.01 m x 1.25 m/s = 0.01 m^3/s
- Daily operation = 20 hr/d
- Daily throughput = 20 hr/d x 3600 s/hr x 0.01 m^3/s = 720 m^3/day
- 1 L slurry = 1285 g/L (filled water bottle with slurry entering the sluice)
- [33]Mass of sediment in slurry = 463 kg/m^3
- Ore Throughput = 720 m^3/d x 463 kg/m^3 = 333360 kg/d = **333 T/d**

This estimate of 333 T/d of ore throughput from the spurting-suction-sluice system is higher than the expected average daily throughput reported by the small-scale mining company, once corrected for down time (200 T/d). It should be noted that there is a large inherent error given the rudimentary measurement techniques applied, particularly with respect to the water flow rate, as calculating flow velocity and depth is difficult. While the variation between 200 and 333 T/d is large, it is within one order of magnitude, and demonstrates that the reported information from the SSM companies is more or less in line with simple throughput calculations based on rudimentary measurements. Slight adjustments to the measurements within the range of error could easily account for the discrepancy between reported and calculated throughputs.

A second throughput estimate was conducted for a crusher-sluice system by estimating the size of the pile of material to be treated, and the amount of time needed to treat it. This, coupled with an estimate of the density of sediment, can be used to estimate the total daily production in tonnes. An ore pile size was estimated, and a miner was asked how long it would take to treat the pile. These are VERY rough estimates, but are used to see if the daily throughput is feasible according to other throughput estimates. Additionally, the group had been working the same ore source for a few months and reported average recovery of 80-200 g per 4 day processing batch, allowing grade estimates to be completed as well.

Cross Check 2:

- Ore pile size: 30 m^3
- Time to process: 5 hr
- Throughput = 6 m^3/hr
- Operational: 20 hr / d
- Daily throughput = 6 m^3/hr x 20 hrs/d = 120 m^3/d
- Ore pile density: 1.6 T/m^3 (calculate solids only)
- Throughput: 1.6 T/m^3 x 120 m^3/d = **192 T/d**

[33] Calculated using sediment density of 2.6 g/cm^3 (quartz/feldspar mix), water density of 1.0 g/cm^3 and slurry density of 1.285 g/cm^3.

- Batch length = 4 d/batch
- Throughput/batch = 192 T/d x 4 d/batch = 768 T/batch
- Grade: 80-200 g / batch
- Grade: **= 0.10 – 0.26 g/T recoverable**

The second throughput calculation for crusher – sluice systems suggests a lesser throughput of 192 T/d compared to 333 T/d from the Spurting – Suction – Sluice systems. The calculated 192 T/d and 333 T/d for these systems based on field observations suggests that the downtime corrected estimate of ~200 T/d reported by SSM company representatives is feasible. To improve estimate confidence, a greater number of systems should be evaluated using multiple lines of evidence to cross check throughput, production and grade estimates. For now, we use **200 T/d** production assuming 24 hour operation. This could be one system operating 24 hr/d, or two systems each operated 12 hr/d.

8.4 Ore Grade

Determining ore grade can also be difficult, particularly when using questioning active miners as a primary information source. As miners have limited knowledge of throughput in terms of mass, understanding recoverable ore grades is even less likely. Miners often refer to ore grades as grams of gold produced per barrel of fuel consumed during processing, rather than per tonne of material processed. To get an idea of general recoverable ore grades discussions were held with MSM companies who apply similar (albeit improved and optimized) processing techniques to those applied by artisanal miners.

Grassalco reports that its ore has a true ore grade of ~1.5 g/T, with about 50% recoverable, or 0.7 g/T using their optimized systems. Grassalco suggested that artisanal miners operating on their concession's recoverable grades are ~20 % of true ore grades, suggesting **0.3 g/T** recoverable to ASGM. Nana resources reported recovery of ~1 g/T using their system and estimated that ASGM operations recover about half of that, or **0.5 g/T**. The calculated ore grade shown above in the throughput section of **0.1 – 0.26 g/T** is low, but not significantly different than the values suggested by these MSM companies, and may have to do with differing raw ore grades.

8.5 Karatage

Karatage is reportedly very high in Suriname. Miners in the field often report purity in excess of 92%, reaching as high as 97% in some cases. To verify these reported values gold shops were visited who cited ranges from 89-98%.

8.6 Miners per system

The number of miners per system varies depending on the type of system used and the organisation of the mining group. Small simple ground sluice systems may be operated by single miners where as larger more organised groups may have upwards of 10 people per system. Not all of these workers are direct processors, and include excavator operators shared between systems, camp cooks, site managers and the site boss. Larger groups operating mechanised processing systems make up the vast majority of the

Surinamese mining population and gold production. Multiple mining camps were surveyed, and the number of workers per camp were noted.

Crusher Operation 1

- Total number of people camp = 35
- Total number of processing systems = 3
- Shifts/day = 2
- Workers / system = 11.7
- **Workers / shift = 5.83**

Crusher Operation 2

- Total number of people camp = 16
- Total number of processing systems = 4
- Shifts/day = 1
- Workers / system = 4
- **Workers / shift = 4**

Spurting/Suction Operation 1

- Total number of people camp = 10
- Total number of processing systems = 1
- Shifts/day = 1
- Workers / system = 10
- **Workers / shift = 10**

Spurting/Suction Operation 2

- Total number of people in camp = 5
- Number of processing systems = 1
- Shifts / day = 1
- **Workers / shift = 5**

Spurting/Suction Operation 3

- Total number of people in camp = 13
- Number of processing systems = 1
- Shifts / day = 2
- **Workers / shift = 6.5**

Spurting/Suction Operation 4

- Total number of people in camp = 8
- Number of processing systems = 1
- Shifts / day = 1

- **Workers / shift = 8**

Ground Sluice Operation 1

- Total number of people camp = 6
- Total number of processing systems = 1
- Shifts/day = 2
- Workers / system = 6
- **Workers / shift = 3**

Ground Sluice Operation 2

- Total number of people camp = 2
- Total number of processing systems = 1
- Shifts/day = 1
- Workers / system = 2
- **Workers / shift = 2**

The average number of workers per shift from the working groups surveyed is **5.54 workers/shift**. It should be noted that these shifts represent single shifts per day, and that the 200 T/d production estimate per system is assuming 24 our production, or 2 shifts per day. Therefore, number of workers per shift must be multiplied by 2 shifts per day to produce the total work force required to produce the 200 T/d from above. This suggests that **11.08 workers/d** are needed to produce 200 T/d.

In reality we see that 3 of 8 systems were in operation 24 hr/d.

8.7 Miner Earnings

A series of miner interviews suggests that miners typically earn between 20-30 g Au/month. At the average price of 35 USD/g received by miners in the field for their gold, this suggests monthly earnings per miner of 875 USD, or annual earnings of 10,500 USD. In 2002, the *Cooperativo de Garimpeiros Suriname* (COGASUR), an interest organization for Brazilian ASGM in Suriname, estimated that the average Brazilian miner earned between US$ 500 and US$ 1500 a month (Healy and Heemskerk, 2005). This figure compares well with our estimate.

8.8 Hg:Au ratio

Determining mercury usage on ASGM sites in Suriname can be difficult. Due to the long processing periods and seemingly arbitrary timing of mercury addition, producing physical measurements is nearly impossible without passing extensive periods of time on site. Hiring a miner to measure mercury added and recovered during the processing workflow is a possibility; however, without monitoring it is difficult to verify if the miner truly measured the information, and did not miss any additions. The miner must be fully trusted for the information acquired to provide value. Miner and processor surveys may be a useful tool for gaining information on mercury use; however, miners are often hesitant to provide mercury

related information, and even if they do, may not truly know the amounts added or recovered as this is not something they measure or are concerned with.

During site visits many miners were asked about mercury usage. It is fundamental that mercury use and gold production over a set processing period be defined. As miners rarely know what the amount of mercury added or recovered during a processing period, it was found that determining the amount of mercury bought over a period, and the average amount of gold produced over the period was the best way to get the information needed to produce Hg:Au ratios. Information gathered and Hg:Au ratio estimates produced are included below.

Miner 1:

- Work 4 day batches between cleans
- Work about half the month (16 days, or 4 batches/month)
- Recovered 80 g last batch from one system; usually get ~200 g/batch
- 94 % pure Au
- 24 k Au production/batch = 75.2 to 188 g
- 24 k Au production/month = 300.8 to 752 g/month
- Buy 1 kg/month
- Hg:Au ratio = **3.32:1** to **1.32:1**

Miner 2 (*same site as 1****)*****:**

- Reported loss of 500 g Hg/batch
- 24 k gold production/batch = 75.2 to 188 g
- Hg:Au ratio = **6.62:1** to **2.64:1**

Miner 3 (*same site as 1****)*****:**

- 3 kg Hg added to a crusher each batch
- Lose 20 % of Hg added = 600 g Hg lost/batch
- Run 4 batch/month = 2400 g Hg lost/month
- 24 k Au production/month = 300.8 to 752 g/month
- Hg:Au ratio **= 7.98:1** to **3.19:1**

Miner 4:

- Batch 1 used 200 g Hg, recovered 59 g Au
    - Hg:Au = **3.39:1**
- Batch 2 used 500 g Hg, recovered 300 g Au
    - Hg:Au = **1.67:1**

Miner 5:

- In a week produced 150 g of 92 % Au

- 24 k Au = 138 g/wk
- Uses 200 g Hg/wk
- Hg:Au **= 1.45:1**

Miner 6:

- 350 g Au/wk at 92 % pure
- 24 k Au = 322 g/wk
- Uses 500 g Hg
- Hg:Au = **1.55:1**

Miner 7:

- 10 kg Hg used
- 3 kg Au produced
- 94% pure
- Hg:Au = **3.55:1**

Taking an average of all Hg:Au ratios produced from information gathered from interviews yields an average Hg:Au ratio of **3.34:1**.

8.9 Cross checking existing ASGM estimates

Some simple crosschecks may be applied to existing inventory information, using information gathered from interviews and field visits, to determine if the existing inventory information makes sense.

Cross Check 1: ***Amount of ore, processing systems, and workforce needed to produce 18.85 T of gold***

We will first cross check total ASGM gold production reported by the central bank by calculating the total ore, number of processing systems, and workforce needed to produce this amount of ASGM gold.

Total Annual Au production = 18.85 T
Average ore grade = 0.5 g/T
Active days of production = 180 d/yr
Daily throughput = 200 T/d/system
Workers per shift = 5.54
Shifts/system = 2

1) Calculate ore processed per year:

(18.85 T Au/yr) x (1,000,000 g/T) ÷ (0.5 g Au/T ore) = (**37,700,000 T ore / yr**)

2) Calculate processing systems required to produce this ore (assume active 24 hours):

(37,700,000 T/yr) ÷ (180 d/yr) ÷ (200 T/d/system) = (**1047 systems**)

3) Total workforce required to produce this gold:

(1047 systems) x (5.54 workers/shift) x (2 shifts / systems) = (**11,603 workers**).

Notes:

- As only 3 of 8 observed processing systems actually operate 2 shifts per day, this 1047 2-shift systems is more likely broken into 392 2-shift systems, and 1310 1-shift systems.
- Had the lower gold grade of 0.3 g/T derived from GRASSALCO been used, then **19,339 workers** would have been required to produce this 18.85 T of gold. This demonstrates the large variability in results based on small changes to input variables, further demonstrating the importance in constraining inputs as well as possible, and applying multiple lines of evidence to cross check results.

Cross Check 2: ***Determine workforce needed to produce this 18.85 T of gold using known gold using miner earnings estimates.***

A second cross check uses the total annual ASGM gold production value, coupled with the reported earnings of individual processors, and the proportion of processors to other workers in a mine camp to determine the amount of workers needed to account for this production.

Monthly miner earnings = 25 g/month
Total Annual ASGM gold production = 18.85 T
Percentage of total gold production paid to processors = 20 %
Percentage of work force composed of processors = 80 %

1) Calculate total grams of gold earned by processors:

(18.85 T/yr) x (1,000,000 g / T) x (20 % miner share) = (**3,770,000 g/yr to processors**)

2) Calculate total number of processors:

(3,770,000 g/yr) ÷ [(25 g/month/processor) x (12 month/yr)] = (**12,567 processors**)

3) Calculate total number of workers

(12,567 processors) ÷ (80%) = (**15,709 workers**)

This value of 15,709 miners is in close agreement with the previous miner population estimate from the production cross check using a grade of 0.5 g/T, as well as the estimate of ~10,000 miners provided by the OGS.

8.10 Proposed Inventory Methodologies for Suriname

Collecting field based inventory data for ASGM countries is always challenging, and Suriname is no exception. Furthermore, using this data to produce national estimates is even more difficult. These methodologies are meant to simply propose options for acquiring useful inventory data, and have not been tested in the field. Further development of methodologies is required, and methodologies are proposed to show examples of how various information acquired from various sources may be used to produce and cross check inventory estimates. It should be noted that all inventory techniques have some inherent sources of error, which must be identified and considered during data acquisition and assessment. Triangulation of inventory estimates from various sources is essential in reducing uncertainty in estimates, and is key to identifying flaws in specific data acquisition and deduction approaches when producing inventory estimates.

8.10.1 Processing Equipment Estimates

A processing based inventory methodology may be applied; however, this method must be used cautiously as there are a variety of different processing workflows applied in Suriname, and the throughput and recovery between methods (and even between groups using similar methods) can vary significantly. To apply the processing based methodology the primary types of processing systems and workflows must be defined. Then, for each workflow, an idea of throughput, grade, and karatage must be determined. Throughput may be determined by measuring the flow of material through a system (as shown in cross checking section for sluices), by questioning miners (they may not truly know), or by assessing the size of piles of material processed and asking or observing how long it takes to process this material (then calculate throughput as shown in the cross checking section). Grade may be determined once throughput is known by observing or asking miners how much gold they recover on average per batch of material processed. Karatage is generally well constrained for sites, and miners know the purity of their gold. With these three pieces of information a production estimate can be made for a specific system. The workforce required to operate the systems may be simply counted. It should be noted that a camp may also employ an excavator operator that is shared between systems, foremen, bosses, and cooks, who will not directly operate machinery, but together make up the active mining group team. Mercury measurements may be conducted by asking trusted miners to measure mercury added and recovered from a system, and an Hg:Au ratio can be determined if the amount of gold produced over the experimental period is known. Alternatively, miners can simply be asked how much gold is produced and how much mercury is bought for a period of time. The information above can be used to produce an average gold production, mercury usage, and miner population for a specific type of system.

Repeating the process described above for multiple groups operating the same types of system will allow for the calculation of production, mercury usage, and workforce averages for the specific system type. This should be completed for all system types observed. Once this is completed, system types on a site may be counted, and the averages applied for the number of each system to determine site wide estimates. Ideally this would be applied to all active ASGM sites; however, this is not realistically feasible given the amount and geographically diverse location of sites. To extrapolate nationally an understanding of the number of sites, their general sizes, and an understanding of the amount of each systems on the

sites must be produced, to which the averages for the systems may be applied. This could be produced by interviewing concession holders or local community leaders who will have an idea of the amount of ASGM, and perhaps of each processing system type, on their lands. There is significant room for error in this approach; however, it yields insight into processing workflows and returns, mercury consumption for the various processing workflow, and demographics for miners working various system types. Additionally, the estimates produced from the processing based methodology provide an additional crosscheck for other estimates produced using other methods.

8.10.2 Excavator Based Estimates

The presence of excavators is often a good indication of levels of production on a site. Excavators may be shared amongst groups or dedicated to single groups alone. The amount of material moved per excavator can be used to yield an estimate of throughput. Excavators are used to extract ore, and to pile it up in advance of processing. The amount of scoops per pile could be used to calculate total volume, and this, coupled with density of loose sands, can be used to determine the total tonnes of ore in the pile. If the excavator produces, for example, 10 piles per day, and it is found that each pile holds 10 tonnes of ore, then the daily production for that excavator is 100 tonnes. Miner surveys, or direct observations may yield the grade per pile (by determining how many piles are processed in a batch, and the gold recovery in a batch), which can then be used to estimate daily gold production per excavator. Mercury usage could then be estimated by applying a Hg:Au ratio to the gold produced per excavator, and site wide estimates could be formed by counting excavators per site and applying production per excavator to the total site. This estimate will exclude the operations of small groups or single miners using ground sluices, metal detectors or panning; however, the production from the smaller groups is significantly less than the larger operations, and may not have a large impact on total production.

Total excavators in operation for ASGM may be estimated by speaking with excavator dealers, and determining annual sales, as well as percentage of sales made to mining groups. Total excavator sales to miners could be used as a cross check for other production data by applying the gold production/excavator ratio determined from the method outlined above to total excavator sales to miners. This is not a refined technique, and must take into account many sources of error (older excavators already in the field, some break down, not operational all the time, days used per year, etc); however, is included as an example of the many possible ways and lines of evidence that can be applied to determine inventory estimates, and to cross check results.

8.10.3 Fuel Consumption Estimate

In Suriname it has been observed that miners and mining groups typically report grades as g/barrel of fuel rather than by g/T of ore processed. This is an interesting piece of information. Most mining regions of the world use g/T of ore processed as a measure of the value of the ore processed; however, in Suriname, (and alluvial in general), the amount of material moved is so large quantifying its mass is difficult. An easier approach is to quantify the amount of fuel used during processing. This is easy as fuel barrels consumed can be counted and recorded by miners. This is important to miners as fuel is a direct expense and the

largest expense in the operation[34]. Understanding the amount of gold produced per barrel of fuel consumed is therefore an excellent measure of success, and most mining operations have a goal production (ex: 35 g/barrel), and an economic cut-off (reported at 15-18 g/barrel).

Understanding the average recovery in g/barrel of a group, as well as the economic cut-off (could be used as minimum production amount as miners will not continue producing below this point), can be useful in conducting inventories. If this average gold production per barrel is known, and the daily, weekly, or monthly fuel consumption of a group, the total gold production per unit time can be estimated. The total number of miners in the camp can be counted to determine population, and an Hg:Au ratio may be applied to the gold production to determine total Hg use. This may be an excellent approach for inventory estimates in Suriname as the vast majority of miners encountered use this g/barrel of fuel metric for measuring production.

8.10.4 Concession Holder Based Estimates

Concession holders and local community leaders may be a valuable source of information as well. A list of concession holders and their contact info may be available from the Foundation for Holders of Mining Rights (*Stichting Houders Mijnbouwrechten*). Concession holders generally receive payments from the miners working on their concessions, typically 10 percent. Interviews with concession holders might reveal some information of earnings or production. Even if concession holders do not want to share this information, which most of them won't, concession holder interviews could reveal information, such as the number of ASGM camps on the concession, the total ASGM population (and hence work force per piece of equipment), the types of processing systems, and so forth.

Similar to concession holders, local community leaders may extract royalties from mining groups working on their lands. These leaders may also be interviewed to extract similar kind of information

8.10.5 Export data Estimates

As discussed previously, export data can provide insight into ASGM gold production. This is often a good starting point against which other inventory estimates may be checked. Total annual export minus production from LSM and MSM can be used to produce ASGM production. This assumes all gold exported is produced in Suriname, and that no gold produced in Suriname remains in the country, or leaves illegally.

8.11 Initial Mercury Use Estimate

In an attempt to produce an initial mercury use estimate for Suriname, the CBvS reported national ASGM gold production estimate is coupled with rudimentary Hg:Au ratio produced from initial field visits. It should be noted that there is a large potential bias associated with using either of these pieces of information, and that further study, cross checking, and data refinement is needed to improve these estimates. However, these data yield a first glimpse into potential mercury usage in Suriname.

[34] From the expenses recorded for different operation, we estimate fuel expenses at 70% of total expenses.

Using the gold production estimate of 18.85 T/yr, and the Hg:Au ratio of 3.34:1 suggests annual mercury emissions of 63.0 T Hg/yr. For all reasons mentioned above, this value is uncertain. Because the minimum amount of mercury needed to amalgamate gold is 1:1, the minimum amount of mercury would be 18.85 T. This low-end estimate assumes no loss to environment during amalgamation, and 100% loss of Hg in the amalgam ball during burning. The 100% loss during burning is realistic as retorts are rarely used and amalgam is commonly burned in an open-air environment. Sometimes miners cover amalgam with leaves during burn to condense vapour, but the amount, if any, mercury recovered in the process is unknown. The assumption that no mercury is lost during the amalgamation process in the 1:1 ratio is not realistic, as all miners observed practice whole ore amalgamation in an unconfined system, which is renowned for low mercury efficiency and high losses to the surrounding environment.

9. CONCLUSIONS AND RECOMMENDATIONS

The main objective of this study was to improve the understanding of the ASGM sector in Suriname and to assess the viability of, and develop plans for, future technical interventions focused on mercury reduction on active ASGM sites. The report assembled existing yet dispersed data about the ASGM sector in Suriname, presented new information based on stakeholder consultations and field observations, suggested ASGM inventory methods that may be replicated by others, and provided an informed estimates of the average Hg:Au ratio and total amount of mercury used in the Suriname ASGM sector.

The feasibility of future interventions by the AGC or other groups aimed at promoting Hg-free mining, and the content and structure of these interventions, depend on many factors. These factors include: (a) the political climate, (b) the technical capacities and skills of ASGMs, (c) the investment possibilities of ASGMs, (d) the legal framework, and (e) the presence of facilitating partners in Suriname.

(a) With regard to the political climate, it is evident that an Hg-free mining project is compatible with the government vision on ASGM and the use of mercury therein. The GoS has taken preliminary steps to ratify the Minamata Convention, and gradually phasing out mercury from ASGM is a national policy priority. This favourable policy climate means that an Hg-free ASGM project can likely count on government support. Such support may be requested in the form of tax breaks for the import of Hg-free ASGM equipment, the allocation of a project area and access to information.

(b) The discussion of currently-used ASGM processing techniques shows that ASGM miners have extensive experience with the use of excavators, milling systems, and sluicing. The example Hg-free work flow (Figure 17) demonstrates that with small alterations and additions to current processing systems, current operations can become Hg-free. The earlier Surgold-supported project with a concentrator and shaking table also showed that the additional pieces of equipment are intuitive, easy to use, and convincing.

(c) The high level of mechanization of ASGM operations implies that many gold miners in Suriname invest considerable amounts of money in their operations. Mining entrepreneurs who invest in excavators, crusher installations and hydraulic motors should also be able to invest in centrifuges and shaking tables *if they are convinced that this equipment will give a good return on their investment*. A challenge, therefore, is to convince ASGMs that this equipment works and can repay the initial capital investment through increased recovery quickly. This means that in addition to processing system operation and optimization training, intensive hands-on training in mining and mine development (incl. prospecting), and guidance in the field, are crucial to efforts aimed at promoting Hg-free equipment. If gold miners do not prospect, and start using Hg-free ASGM equipment in an area where there is insufficient gold, or if they use the equipment inadequately, their earnings will most likely be disappointing and possibly not even cover the fuel expenses. In such cases, ASGMs may become discouraged and loose believe in the particular pieces of equipment and in Hg-free mining in general.

(d) The single most difficult challenge is Suriname's legal framework and the practical execution thereof. The AGC promotes the production of artisanal gold that is conflict-free, mercury-free, and mined legally. At this moment there are very few, if any, ASGMs who work legally and in compliance with the Mining Decree. The selection of a suitable pilot location will therefore not be easy.

In a possible collaboration with Surgold, for example, the AGC will not be able to work with ASGM within the Merian ROE because these ASGM operations are no legal partners of Surgold. Also outside yet in the vicinity of the Merian RoE there are no ASGMs who possess a legal mining title. The GoS established a Pamaka Mining Reserve near Merian to provide an area where ASGM would be able to apply for small-scale mining titles. However, few mining operations are active in this Reserve, and those who are have not obtained the required mining title[35]. Surgold negotiates with the GoS to find a way to legalize local ASGM operations so that they will become suitable as an AGC pilot project site.

(e) In order to guarantee projects sustainability, it would be useful to partner up with other organizations that could support the financing, implementation, and monitoring of Hg-free mining projects. Conservation NGOs (CI Suriname, WWF-Guianas) and international donor organizations (UNDP, World Bank) have expressed interest in projects aimed at reducing and eventually eliminating mercury from the Suriname ASGM sector. Also, by signing the Minamata Convention, Suriname may become eligible for additional external funding sources to help Hg reduction programs.

The AGC also identified Surgold as a possible project partner. Surgold has an extensive infrastructure, existing relations with ASGMs, and field presence. The promotion of Hg-free ASGM is among Surgold's commitments to the local community, and a pilot project in the vicinity of the Merian RoE would align with this commitment. Surgold also has an existing working relation with UNASAT, which could be another useful project partner, particularly in terms of training of ASGMs, monitoring, providing feedback, and other forms of field assistance.

Finally, it is observed that there are few examples of successful efforts to reduce or eliminate mercury from ASGM processing in Suriname. Any project should have a carefully planned monitoring and evaluation component so that the lessons learned can be used in other areas.

[35] The Mining Reserve is not an area where ASGM can legally mine as they please, but it delineates an area where ASGMs can apply for a small-scale mining titles. To date, no small-scale mining titles have been allocated for operations in the Pamaka Mining Reserve.

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ANNEXES

Annex 1. Mercury measurements in Suriname

Atmospheric mercury

Atmospheric mercury has been measured by ADEK University physics lecturer Mr. Wip. Using a portable Lumex RA-915+ portable analyser, Wip has measured Total Gaseous Mercury (TGM) in and around gold buying houses in Paramaribo city. In some occasions, these measurements took place in collaboration with the Bureau Public Health (BOG) and the Ministry of Labour, but it in two instances the gold shop owners requested the measurements.

Both inside and the close vicinity (<100m of some of the gold buying shops high TGM levels have been measured. In a 2011 study, TGM levels outside the gold buying shops ranged between 0.5 and 10 µg/m^3 and inside the shops between 0.5 and 60 µg/m3[36] (Wip et al. 2011). Follow-up measurements suggest that these TGM values have been rather consistent around the same gold shops over time[37] (D. Wip, senior lecturer in physics ADEK University, pers. com. May 4, 2016). The higher concentrations surpass the National Institute for Occupational Safety and Health recommended exposure level of 50 µg/m3 inside and the minimal risk level of 0.2 µg/m3 of the US Agency for Toxic Substances and Disease Registry (ATSDR) outside. According to Wip, the main cause of high atmospheric mercury levels around gold shops is poorly functioning fume hoods and retorts (pers. com. 4 May 2016).

Wip also measured TGM in one of the gold mining areas, namely the Benzdorp area. In this location, the overall value of total gaseous mercury (TGM) was ~ 400 ng/m3, but in locations where gold miners reworked materials from tailings, values of up to 30,000 ng/m3 were measured.

The Medical Bureau Occupational Safety and Health (OSH) of the Ministry of ATM also conducts measurements of mercury emissions in and near gold buying centres, and plans to conduct bio-monitoring (J. Courtar, Head Medical Bureau OSH, Ministry of ATM. pers. com. 30 July 2014). On the basis of its findings, the department labour inspection of this same ministry can come into action where necessary.

Mercury in fish and people

Measurement of mercury in sediments, water, fish and people is performed by the academic researcher Dr. P. Ouboter of the National Zoological Collection of Suriname/ Environmental Research Center (CMO) and by the Central Lab of the Bureau for Public Health (Dr. J. Quik).

Fish: Since the late 1990s, studies have consistently reported elevated to high[38] mercury levels in bottom sediments and tissues of predatory fish in most gold mining localities, as well as upstream (Ouboter,

[36] The WHO safe standard is 1 µg/m^3

[37] Previously, Mr. Wip did weekly rounds to measure atmospheric mercury on fixed locations along a fixed route. Nowadays, due to a lack of funding, measurements are more intermittent.

[38] Surpassing the European standard for human consumption of piscivorous fish of 0.5 µg/g (EC, 2002).

2015). The highest levels have been recorded for the Brokopondo Reservoir, where piranhas were sometimes six to seven times the norm for human consumption (on average two to three times).. Mercury levels in the downstream sections of the rivers were generally lower. High mercury levels also have been found in fish in most of central and western Suriname far from any gold mining activity. These high mercury levels High mercury levels in undisturbed areas to the southwest of the gold mining areas are explained by the atmospheric transportation of mercury by the northeastern Trade Winds, wet depositing of mercury, especially in areas of high precipitation and the high bio-availability of mercury in unpolluted streams. A 2010-11 study in collaboration with Tulane University in a Maroon (Kwakoegron) and an Indigenous (Pikin Saron) community found that of the fish caught in the area, 75% was above the WHO norm for human consumption (Ouboter 2015).

People: Also since the late 1990s, different Suriname researchers found elevated levels of mercury in gold mining populations and inhabitants of nearby communities. At the same time, two independent French studies reported alarmingly high levels of mercury in Indigenous Wayana villages along the Lawa River (border between Suriname and French Guiana). In some villages up to 79% of the children had hair mercury levels above the NOAEL level of 10µg/g.A couple of years later, Ouboter and co-workers found elevated mercury levels in Maroon communities along the Saramacca River. A survey on the request of inhabitants of the Maroon community of Brownsweg, showed that of 172 participants, only 2 persons were above the NOAEL level of 10 µg/g. Brownsweg, however, is located on just two hours driving from Paramaribo, and many inhabitants earn cash income. In general, the various studies showed that villages with easy access to the capital, show lower mercury pollution because people are less dependent on local fish as a protein source (Ouboter 2015).