Global Mercury Project

Project EG/GLO/01/G34:
Removal of Barriers to Introduction of Cleaner Artisanal Gold Mining and Extraction Technologies

SUMMARY REPORT: TECHNICAL AND SOCIO-ECONOMIC PROFILES OF GLOBAL MERCURY PROJECT SITES

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May 2004

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The information presented herein has been taken from commissioned socio-economic assessments and reports by the Assistants to the Country Focal Points (ACFPs) conducted in each of the Global Mercury Project target regions. Additional input was received from project consultants and ACFPs throughout the preparation of this summary report. The authors would therefore like to recognize the contributions of the following individuals and their project teams: Saulo Rodriguez (Brazil, Indonesia), Roberto Villas-Bôas (Brazil Indonesia), Armin Mathis (Brazil), Rachmadhi Purwana (Indonesia), Selinawati T. Darmutji (Indonesia), Marcello Veiga, Eravanh Boungnaphalom (Lao PDR), Earth Systems Lao (Lao PDR), Mohamed S. Ibrahim (Sudan), Khalil A. Al Medani (Sudan), Susan Wagner (Tanzania), Aloyce L. Tesha (Tanzania), Dennis Shoko (Zimbabwe), Celani Mtetwa (Zimbabwe) and Soul Shava (Zimbabwe).

INTRODUCTION

The Global Mercury Project (GMP) is located in communities and mining areas within six participating countries – Zimbabwe, Tanzania, Sudan, Brazil, Indonesia and Lao PDR. Project sites were selected based on the importance of artisanal and small scale mining (ASM) in these regions and the proximity of communities[1] to international waters that may be impacted by ASM, particularly with respect to pollution generated from the misuse of mercury. Although the project sites differ somewhat in terms of population, geography, cultural context, mining practices and mining history, they share a critical similarity – ASM represents an essential source of livelihood.

This chapter summarizes the results of commissioned socio-economic assessments and reports by the Assistants to the Country Focal Points conducted in each of the mining communities which will directly benefit from Global Mercury Project (GMP) activities. In addition to collecting baseline information on community demographics, ethnicity, economic activities, and quality of social services and infrastructure, among other socio-economic data, the socio-economic profiles sought to characterize the significance of ASM in these regions, with special emphasis on perceptions concerning mining practices, particularly in relation to mercury use. These evaluations further attempted to capture the gender dimension of ASM in these regions, thereby providing a basis to effectively address gender barriers through the GMP. Reports by the Assistants to the Country Focal Points compiled detailed information on mining practices and gold production in these communities and provided a basis for a preliminary assessment of anticipated environmental and human health impacts, as summarized herein.

Project Site Descriptions

Kadoma-Chakari Region Zimbabwe

Located within one of the largest gold belts of Zimbabwe, the Kadoma-Chakari region has the highest density of small scale gold miners, millers and panners of all of the country's gold belts. Geographically, the area is located about 150 km south-west of Harare along the main Harare-Bulawayo highway in the Zambezi Basin. Access into the mining areas from Kadoma City is very good along paved all-weather roads and good dry season roads. The Zambezi Basin and its water resources are shared by eight of the fourteen Southern African Development Community (SADC) states. The long-term environmental well-being of the Zambezi River, its tributaries, and associated dams and lakes depend on the type and scale of economic activities that take place within the basin.

In addition to mining, important activities include urbanisation, logging, agriculture, manufacturing, and tourism. Agriculture is the primary economic activity for the 6354 people living in the project site region. However, ASM represents an increasingly important source of income with 23% of survey respondents alternating mining with farming activities. Participation in ASM has increased markedly since the 1990's when downscaling of the nearby Dalny Mine led to a significant rise in unemployment. It is

[1] The term *community* is used loosely to refer to the village, area or region where ASM represents an important component of the local economy.

estimated that 300,000-400,000 artisanal gold miners are active and directly and indirectly benefiting at least two million people (Shoko, 2002, Maponga and Ngorima, 2003).

Rwamagasa Village, Tanzania

In Tanzania, ASM is most significant in the Lake Victoria Goldfields – specifically the Geita, Rwamagasa, Kahama, Musoma-Mara, Nzega and Kilimafedha belts - which produce more than 95% of the country's gold. Given the intensity of ASM, environmental and human health impacts from these activities are also most pronounced in this region. Geita, which is one of the seven districts of Mwanza Region lying Southwest of Lake Victoria, has the largest numbers of miners than any other district and is comprised of four major ASM centres, namely Nyarugusu, Nyakagwe, Mgusu and Rwamagasa.

In the Rwamagasa belt, gold mineralisation occurs in quartz veins as well as secondary enrichment in rubble at the base of laterites overlying subsurface greenstone rocks. Rwamagasa village, located in the heart of the Rwamagasa belt, is the target of the GMP. Rwamagasa Village is divided into 5 *vitongoji* (sub-villages): Elimu, Isenyi, CCM, Lubinga and Imalanguzo, all of which strongly depend on the services available in nearby Geita town.

In Rwamagasa Village, the local population (26,990 people) relies on ASM in conjunction with livestock, farming and fishing. The majority of residents rely solely on ASM (54%), while 14% conduct mining in conjunction with farming and small business enterprises. Although many residents are driven to ASM by economic hardship (21%), particularly since the late 1990's, a great number do so out of family tradition (78%). Subdivided into five subvillages, Rwamagasa village is comprised of 5,017 households having an average size of 5.4 people.

Ingessana District, Sudan

The GMP-target region in the Sudan consist of mine sites adjacent to Gugub village, which is located approximately 80 km southwest of El Damazin in the Ingessana Hills District of the southern Blue Nile region. The southern Blue Nile region has been known for gold mining since the 19th century although mining did not commence in the Ingessana Hills until the mid-1990s. At that time, civil war along the Sudan-Ethiopia border displaced thousands into the Ingessana Hills and elsewhere. Among these, the Dawalla ethnic group of the Kurmuk district were the first to commence prospecting and are now considered to be the most skilled artisanal gold miners in the region. Eventually, the indigenous Ingessana picked up the skills of artisanal gold mining from the Dawalla, allowing both groups to earn substantial incomes in comparison to other livelihoods. The nomadic Ingessana people traditionally followed the rains from northern to southern regions of Sudan with their cattle herds, a practice which ceased once the southern part of the country was classified as war zone in 1996. The Ingessana were eventually forced to forego their livelihoods, selling most of their herds due to lack of access to water. The population of the GMP-target community, Gugub, is ~800 miners with an additional 300 artisanal miners residing in adjacent villages, Taga and Khor Gam.

São Chico and Crepurizinho, Brazil

With mining activities spanning across 100,000 km^2, the Rio Tapajós Basin area, a major tributary of the Amazon River, is the main gold *garimpo* (artisanal mining site) in Brazil (Silva, 2001). Currently, approximately 50% of the municipality's population is believed to rely on mining, although forestry, fisheries, and agriculture continue to be major sources of livelihood. In the Brazilian GMP-target communities, São Chico and Crepurizinho, ASM has been practiced since 1963 and 1962, respectively. Located in the southwest corner of the State of Pará, Brazil, the communities are approximately 1300 km from the state capital, Belém.

As observed in many of other Brazilian mining operations, or garimpos, the population of both communities have experienced wide fluctuations depending on the price of gold and reports of new strikes, which drew several thousand gold-seekers, mainly from throughout the States of Pará and nearby Maranhão. Crepurizinho, which has some semblance of infrastructure (churches, a police station, pharmacy, etc), currently has a population of ~600, while São Chico has limited facilities (a health post) and is inhabited by only 134 residents.

Talawaan and Galangan, Indonesia

Agricultural activities dominate both areas targeted for ASM assistance in Indonesia, Talawaan in the subdistrict Dimembe, North Sulawesi, and Galangan, also known as Hampalit Village, in the District of Katingan, Central Kalimantan. Talawaan, which is adjacent to Manado, the capital city of North Sulawesi Province, covers an area of 14,000 hectares. With a population of 3817 inhabitants, Talawaan is characterized by intense mining activity, which started in 1998. Two rivers, Talawaan and Bailing River, run directly through the mining area. Galangan is comprised of 17,500 square kilometers, with a population of 8056 people or 2172 households. In Galangan, the mining history dates back to 1980 and has impacted more than 200 km^2. Galangan is adjacent to the Katingan River which flows into the Java Sea 200 km to the south. Agriculture, specifically rice, coconut, coffee and other crops, are important to both Talawaan and Galangan, although these areas are distinctly different in many respects, not only in terms of composition, but with respect to the nature of mining activities.

Lao PDR Villages

The target area in Lao PDR is comprised of eight villages situated along the Mekong River and Nam Ou River in the Province of Luang Prabang, approximately 300 km north of Vientiane. These villages are Ban Thinhông, Ban Houay Koh and Ban Houay Gno on the Mekong River (within the district of Chomphet), and Ban Pak-Ou, Ban Houay Lo, Ban Latthahai, Ban Pakchek and Ban Kiad on the Nam Ou River (within the district of Pak Ou). With 92-98% of the economically active population employed in agriculture, mainly rice production, ASM represents a secondary but much needed source of income.

This region consists predominantly of lowland flood plains, with altitudes ranging from 200 m to 500 m above sea level. The access to the area is either by gravel road of by boat. The latter makes the area more accessible during the rainy season between June and September

SOCIO-ECONOMIC PROFILES

The socio-economic assessments of GMP-target sites are comprised of demographic information on population, ethnicity and origin, education levels, sources and applications of income. These profiles also characterized social infrastructure and amenities, such as the quality of housing, sanitation and water resources, and access to services, as summarized below.

Project Site Demographics

Population Size and Age Distribution

As shown in Table One, there is considerable variability in the population of the participating GMP communities. Of the populations present, in all communities where age data was collected, the majority of mining community inhabitants are in the economically active age range (21-40 years). The older population (above 60 years of age) in all mining communities (where data recorded) is sparse, reflecting low life expectancies. For instance, in the Brazilian target communities only 2.1% of the population is older than 61 years. In both Indonesian communities, 0% of miners were over 60. In the Lao PDR villages, only 6% of the population is above 60 years of age.

Table One: Population and Age Distribution

Region or community	Population	Age Distribution
Sao Chico and Crepurizinho Brazil	134 (Sao Chico) 600 (Crepurizinho)	- average age 25.5 - 28 years old (overall) - 40 years old (mine workers)
Talawaan and Galangan Indonesia	3817 (Talawaan) 8056 (Galangan)	- average age 27 years, range 17 to 56 (Talawaan) - average 35 years old, range 20 to 60 (Galangan)
Lao PDR Villages (8)	3219 (8 villages)	- 51% between 10 and 19 years - 24% between 20-29 - 18% between 30-39
Ingessana District Sudan	5120 (region)*	- 29% between 10-19 years - 22% between 20-39 - 29% between 40-45
Rwamagasa village Tanzania	26,990 (region)	- 37% 30-39 years old
Kadoma-Chakari Region Zimbabwe	6354 (region)	- Miners: 36% 21-30 yrs old; 37% 31-40; 10% 18-20 yrs old - Non-Miners: 40% 21-20 yrs old; 16% 31-40; 20% 18-20 yrs old (non-miners)

* Based on 800 families with national average of 6.4 members per family (UNDP, 2003)

Ethnicity and Origin

Given the migratory nature of ASM and its tendency to attract individuals displaced by extreme poverty and economic hardship, the ethnic diversity of ASM communities is not surprising. All GMP-target communities are of mixed ethnicity, often with multiple languages, as summarized in Table Two. In total, representatives from more than twenty ethnic groups reside in these communities.

Table Two: Ethnicity and Origin

Region or community	Ethnicity and/or Origin
Sao Chico and Crepurizinho Brazil	- Mixed ethnicity, indigenous. - Adults: Maranhão State (51.9%), Pará State (22.2%)
Talawaan and Galangan Indonesia	- Talawaan region and Sulawesi Island - Galangan – Kalimantan Island (51.4%); Java and Sulawesi (48.6%)
Lao PDR Villages (8)	- Ban Pak-Ou and Ban Thingông composed of Lao Loum ethnic group - Ban Kiad composed of Lao Loum, Lue, Phutai, Nhuane and Khmu ethnic groups - In all villages: Lao (45%); Leu (33%); Khmu (19%); Hmong, Nhuane and Phutai (1% each).
Ingessana District Sudan	- Ingessana (indigenous group) and Dawalla (war displaced from Kurmuk district) predominate - Blue Nile Region: the Fung, the Hamag, the Ingessana, the Berta, Falata, Husa, Dawalla, Besie
Rwamagasa village Tanzania	- Walongo, Wasubi, Wasukuma and Wazinza ethnic groups identified - Sukuma tribe from Mwanza region (39%); Muha from Kigoma Region (11%); Kurya from Mara Region (10%); Sumbwa from within the village (6%). Other small tribes (34 %)
Kadoma-Chakari Region Zimbabwe	- Mixed ethnicity. Languages: Shona (mother language of 53% of respondents), Chewa (37%) and Ndebele (9%).

Education Levels

Understanding the educational levels of participating target communities is critical to effectively designing and implementing an intervention, such as the GMP. As shown in Table Three, the assessment of education levels and literacy rates in the GMP-target communities indicate that levels are typically considerably lower than national levels. It is important to note, however, that such a comparison does not provide an indication of relative quality of life in mining versus non-mining communities, as regional data or rural –urban differences are not reflected in national statistics. The importance of regional differences is evident in comparing education levels in the two Indonesian communities. In Talawaan in Sulawesi, education levels are relatively good in comparison to Galangan in Kalimantan, where the rate of secondary school attendance was less than half that of Talawaan. This variability is also observed in Lao PDR, where illiteracy rates range from 7% to 32% in the eight villages surveyed.

The significance of ethnicity in terms of educational levels is most evident in Sudan. The differences are astounding in the Ingessana district, which is predominantly inhabited by the war displaced Dawalla people and the once nomadic Ingessana people. Illiteracy rates reach 90% for the Ingessana and only 2% have attended primary school. It is reported that formal education was previously not viewed as a priority for the Ingessana and was nevertheless inaccessible. Conversely, 95% of the Dawalla have attended primary school and 25% have continued on to secondary school. Since construction of a school by the Dawalla in the mining region in 1998, the majority of the Ingessana now enrol their children in school.

Excluding the Ingessana people, approximately 70% of GMP-community residents have at least some primary education and low levels of illiteracy (averaging 12%). Based on attendance in secondary school, on average, 23% of respondents completed primary school and continued on to secondary school. Low participation rates, particularly in secondary schools, were attributed to the lack of schools and costs associated with attendance (transport costs, accommodation and schooling fees).

Table Three: Education Levels

Region or community		Community Data			National Data[1]		
		Illiteracy (%)	Primary[2,3] (%)	Secondary[3] (%)	Illiteracy (%)	Primary (%)	Secondary (%)
Brazil	Sao Chico	11	35	36	4.5	97	71
	Crepurizinh	20	33	27			
Indonesia[4]	Talawaan	na	28.6	20.3	12.7	92	48
	Galangan	na	53.5	21			
Lao PDR Villages (8)		7 - 32	44	5	34.4	81	30
Ingessana District Sudan	Ingessana	90	2	0	41.2	46	na
	Dawalla	na	95	25			
Rwamagasa Tanzania		10	72	11	24	47	5
Kadoma-Chakari Region Zimbabwe		17	81	50	10.7	80	40

1. Based on national averages compiled in the Human Development Report (UNDP, 2003)
2. Primary school numbers include those respondents who have continued on to secondary school.
3. Due to inconsistency in reporting, it is unclear whether numbers indicate "some" attendance or completion of primary or secondary school.
4. Rates presented are averages of miners and collectors (Purwana, 2003)

Sources of Income and Primary Expenditures

In most GMP-target communities, agriculture is the predominant livelihood activity, although mining can provide the most significant source of economic wealth. As shown in Table Four, the mining communities surveyed generally experienced incomes above national levels. Highest revenues are obtained in Brazil, where mining is the predominant activity in GMP-target communities, although incomes are still considerably lower than national levels, likely due to severe regional disparities. It should be noted that, in general, national data may not reflect regional differences or ethnic disparities in income and should be used with caution.

The main income-generating activity besides mining in the Kadoma-Chakari area of Zimbabwe is farming. Based on survey results, which mainly targeted communities where mining represents an important component of the economy, many people are engaged in mining on a part-time or seasonal basis (23%). Part-time miners tend to be engaged in farming during the rainy season when mine shafts and pits fill up with water and are at risk of collapsing. Approximately 34% and 20% of people are engaged in mining or farming, respectively, on a full-time basis while 7% of people rely on other occupations. Full-time miners are predominantly mill workers whose work is not hindered by heavy rainfall. The average income in the area is Z$40,000 per month (~US$49/mo).

Table Four: Monthly and Annual Income

Region or community	Community Data Monthly (Local Currency)	Community Data Monthly (US $)	Community Data Annual (US $)	National Data[1] Annual Income (US $)
Brazil - São Chico	374.4 R	125	1500	2850
- Crepurizinho	538 R	179	2148	
Indonesia[3] - Talawaan	350,000 Rp	41	492	710
- Galangan	750,000 Rp	88	1056	
Lao PDR Villages [4]	310,000 Kip	38	456	320
Ingessana District Sudan	< 300,000 SP	< 80	< 960	350
Rwamagasa Tanzania	50,000 TSh	44	532	280
Kadoma-Chakari Region Zimbabwe	40,000 Z	49	588	480[2]

1. Based on gross national incomes (per capita) in World Development Indicators 2002 (http://econ.worldbank.org/wdr)
2. Per Capita Incomes for 2002 in Zimbabwe unavailable – 2001 Incomes shown
3. Rates presented for Indonesia are based on incomes of miners
4. Income shown for Lao PDR is per household

Like Zimbabwe, agriculture (farming and livestock keeping), in addition to trading, fishing and mining, is a major economic activities in Rwamagasa Village, Geita District, Tanzania. Among the people interviewed at Rwamagasa village, 54% are engaged in mining alone, while 14% undertake a combination of farming, mining and petty business. Around 9% practice farming alone, 7% buy gold and other minerals and 5% operate bars, hotels and guest houses. The major economic activities for women in Rwamagasa are food vending (*mama lishe*), selling vegetables in the market, working in bars, tailoring and, to a lesser extent, mining. Both men and women are engaged in agricultural activities. Most people (64%) have an income below TSh 50,000 per month (US$48.40/mo), while 24% earn between TSh 51,000 and 100,000 (US$ 44 – 88) and only 3% earn more than TSh 200,000 per month (US$176). Approximately 45% of survey respondents indicated that their expenditures exceeded TSh 50,000/mo and 7% said they spent more than TSh 200,000/mo. The tendency to spend more than the income obtained from a primary occupation is typical of a general pattern in the country, whereby people undertake extra work in order to meet financial needs.

Prior to civil war, the Ingessana in Sudan were wholly dependent on livestock and subsistence farming, which meant seasonal migration of men away from villages. During these times, women stayed home to care for children and cultivate small plots around houses. Although reliance on cattle has ceased as travel to the war torn south is impossible, subsistence farming ("jubraka") continues. Since 1997, gold mining has become the most important activity practiced and is an activity in which all members of the family participate. Prior to gold mining, the Ingessana received no cash income to speak of. Currently, 87% of the Ingessana interviewed earn less than 300,000 Sudanese pounds per month (less than US$ 200/mo). The majority of revenue generated (82%) is used to purchase cattle, and to a lesser extent goats and other livestock.

Both São Chico and Crepurizinho, Brazil are completely reliant on mining or mining-related activities. In São Chico, one-third (32%) of residents are gold miners, while the remaining inhabitants provide associated services, acting as traders (16%), machine owners (5%), restaurant operators (7%), local businessmen (6%), farmers (5%), and service providers (launderers, health agents, mechanics). In both communities, gold is commonly used as currency. In São Chico, the average monthly income is approximately 16 grams of gold, which equates to approximately R$374.40 per month (US$124.80/mo). Incomes are slightly higher in Crepurizinho, averaging about R$538 per month (US$179/mo) for men and R$397 per month (US$123/mo) for women. Cooks who provide services to teams of miners receive about 4 to 5 grams of gold monthly from each member of the team, totalling a wage that ranges between 12g to 30 grams of gold per month or R$264 - R$660 per month (US$88-$220 per month) for one or two teams, respectively.

In Talawaan and Galangan, Indonesia, mining is significant in areas where it immediately takes place although the regions surrounding both the Talawaan and Galangan mine sites rely on agriculture, with cash crops including rice, coconut, coffee, cinnamon, and nutmeg, and fisheries. In Talawaan, earnings vary slightly between miners and millers/processors. Approximately 41% of miners earn on the order of Rp 300,000 – 400,000 per month (US$35-47) up to Rp 2,000,000 per month (~US$220/mo). The majority of mill operators earn Rp 500,000 to 1,000,000 per month (~US$55-110/mo). Most expenditures are for food, which miners purchase from mill operators at costs of Rp 170,000 to Rp 862,500 (~US$20-100/mo). Other expenses include accommodation (~Rp 500,000/mo or US$55/mo), servants (~Rp 200,000/mo or US$22/mo) and clothing, transport, fuel, and medical purposes. The differences in income between miners and mill operators are also evident in Galangan, where 61% of mill operators earn more than Rp 2,000,000 per month and none earn less than Rp 300,000 per month, while 58.4 % of the miners earn Rp 500,000 to 1,000,000 per month and many often earn less than Rp 300,000 per month. As in Talawaan, the main expenditure is for food (~75%).

Between 33 and 40% of the population in the eight villages in Lao PDR are engaged in economic activities with 38 to 45% being too young to participate in economic activities, and the remainder being ill, elderly or otherwise unemployed. The predominant occupations relate to agriculture, mainly cultivation of rice, and fisheries (32-52%). Livestock rearing is also significant as it provides an opportunity to trade within regional markets for locally unprocurable food and produce, and provides a means of protecting against unforeseen events (such as natural disasters and medical emergencies). Less than a few percent of the population are engaged in other occupations, such as sales and clerical work, government posts and teaching, the exception being Ban Pak Ou where 12.4% of the population is engaged in sales and clerical work, mainly in association with a stimulated tourism sector. Although the household cash income in the surveyed villages is typically low, activities such as textile production and artisanal gold mining contribute significantly to the average household income and provide a buffer for unsuccessful agricultural seasons. Despite the potential income that can be generated from mining, it is typically carried out only when other sources of cash income have failed, mining conditions are favourable or when time permits. The average household income ranges

between US $22 per month in Ban Houay Koh to approximately US $63 per month in Ban Pak-Ou, where tourism has had a significant influence on the local economy. The average household income among the eight villages is approximately US $38 per month.

Social Infrastructure and Amenities

Local government and related services and infrastructure are commonly underdeveloped or altogether absent in ASM communities, leaving miners and their families to rely on their own resources for basic amenities. This is generally the case for the GMP-target communities, as evidenced by the quality of housing, water resources, basic sanitation, education, health services, diet, information resources and available energy resources, discussed below.

Housing

There are considerable differences in the quality, style and cost of housing in the GMP—target communities. This variability is not only based on socio-cultural differences, but also relates to whether the community is more of a mining camp, i.e. where miners leave home communities for periods of time, or whether it is a more established community where the family also resides in the mining area.

In the Kadoma-Chakari area, Zimbabwe, workers' housing at mill sites have been described as "deplorable", consisting of thatch, pole and dagga[2] structures that are "hardly suitable for human habitation". Often this temporary housing is constructed by occupants using local materials. In comparison, some miners stay in the Falcon Gold and Glasgow Mill compounds, where buildings are constructed of brick and asbestos with corrugated iron sheet roofs but cost Z$500-Z$1000 per month (US$ 0.61-1.22/mo).

In Sudan, where mining is a family operation, the Ingessana houses are used for cooking food and sleeping, as well as for processing, i.e. grounding ore and gold processing, including amalgam decomposition by burning. A number of occupants also reside in the same household, with 38% of men having more than one wife living in the same household, 42% have more than five children and 25% having at least two children. As there is no private land ownership, Ingessana pay no rents or fees for land occupation.

In São Chico and Crepurizinho, Brazil, 90% and 60% of houses are registered and are provided some services accordingly. Almost all houses in Crepurizinho are wooden (98.1%) and roofed with *brasilit* or aluminium sheets (90.1%) with cement floors. Most homes consist of five rooms, with a living room, two bedrooms, a kitchen and bathroom, generally without an in-house toilet (58.8%). Housing construction is similar in São Chico, but most houses are somewhat smaller, averaging four rooms instead of five. Many houses are used for both commercial and residential purposes.

As it is more of a mining camp than "traditional" community, the housing in Talawaan, Indonesia differs significantly from Galangan. In Talawaan, miners and processors live in

[2] *Dagga*, sometimes known as hemp, is a plant used as a narcotic whose fibers are often used to make rope and other textiles.

barracks-like shelters; made of tarpaulin with no partitions or specific provision for basic sanitation. Shelters, which lack bathroom facilities, are used mainly for cooking and sleeping, as well as mercury storage. In Galangan, only 27% of the miners and 12% of the processors reside at the mine site, while the remainder of miners live with their families at homes typically located within 100 metres of the mine. In addition to daily household activities (sleeping, cooking, washing, etc) 81% of processors' houses and 48.7 % of miners' houses also serve as places to store mercury and/or conduct amalgam burning.

Basic Sanitation

Most homes and mine sites in the GMP-target communities lack basic sanitation services. In Zimbabwe, with the exception of two mills (Glasgow and Coetzee) that provide basic toilets in the form of pit latrines, there are no toilet facilities on all other mill or mine sites visited. Bathrooms are in the form of grass-thatch surrounded structures constructed by the workers themselves. In Sudan, a few households possess latrines while the majority use the bush or abandoned pits for toilets. In Tanzania, people construct latrines for themselves (97%), as well as pits for refuse disposal. The situation is similar in the Brazilian villages, where 77% and 94% of villagers in São Chico and Crepurizinho, respectively, have outdoor toilets. Refuse is deposited in unoccupied areas or burnt on-site. In Crepurizinho, domestic sewage is directed to a dry-sewer (54%) or to an outdoor ditch (46%). In Talawaan, Indonesia, various facilities are used including the bush and forest (~50%), dug-pits (~20%), creeks and rivers (~20%), and water-sealed latrine (~5-9%). In Galangan, water-sealed latrines are used far more frequently (~50%), as are abandoned pits (~75% miners; ~40% processors).

Water Resources

GMP-target communities obtain water from a variety of sources, such as drilled deep wells (boreholes), shallow dug wells, springs, creeks or rivers, rainwater and occasionally flooded pits or mine shafts (Table Five). Typically, water quality is perceived to be good, despite the likelihood of contamination from sewage in some locations and complaints about water muddiness or hardness. In some cases, water sources are located great distances away and must be carried, as is the case for some residents of the Kadoma-Chakari Region in Zimbabwe, who must travel up to 5 kilometres to fetch water. In many locales, water is obtained from multiple sources depending on its use. In Rwamagasa, Tanzania, water used for washing and bathing is predominantly taken from boreholes (63%), while that used in sluicing is taken from ponds and mine pits (40%) as well as boreholes (15%). Sources also vary seasonally, as observed in Ingessana District, Sudan, where boreholes, springs and mountain runoff are used for washing, drinking, and mining in the rainy season and in the dry season, water must be transported from mountain springs.

Table Five: Water Sources and Quality

Region or community	Water Source: Borehole Well	Dug Well	Spring or Creek	Other/Comments	Perceived Quality
Brazil - São Chico	P	S1	S2	- rainwater collection also	na
- Crepurizinho		P			
Indonesia - Talawaan		P	S	- Tal: Talewaan Rivr	Good
- Galangan	-	S	S	- Gal: Abandoned Craters (Primary) - Bottled water (S)	Poor
Lao PDR Villages	-	-	P	- creeks for most villages	na
Ingessana District Sudan	S	-	P	- springs used as a primary source in the rainy season	Good (85%) Salty Taste (dry season)
Rwamagasa Tanzania	P	S1	S2		Good (70%) Muddy (15%)
Kadoma-Chakari Region Zimbabwe	P	-	-	-Pumped from old mine shafts - Carried from wells or springs, up to 5km	Good

P = Primary Domestic Water Source
S = Secondary Domestic Water Source (S1 more significant than S2)
na = not available

Although water is frequently perceived to be of good quality, various types of water treatment have been used. In Rwamagasa, Tanzania, 70% of respondents consider the quality of water to be good, while the majority of residents treat the water by boiling (68%) or filtering (12%). The remaining residents use chemical treatment, buy mineral water or use the water in its untreated form. Inhabitants of Crepurizinho, Brazil are also concerned with water treatment, with only 15% drinking untreated water and the remainder relying on chlorination (57%) or water filters (20%).

Contrarily, residents of São Chico, Brazil generally do not treat their water before consumption. In other GMP-target communities, the water poses an evident health risk, but high-risk practices continue. For instance, in Ingessana District, Sudan, residents do not boil drinking water, despite speculation about pathogenic contamination (e.g. giardia). In Talawaan, almost 100% of residents also do not employ treatment measures. Fortunately, in Galangan, where 58% of miners use abandoned mine pits for *both* disposal of sewage and collection of drinking water, almost all residents boil water before consumption. Galangan residents recognize that water quality is poor and also employ other treatment measures, such as sand filtration and coagulation or simple sedimentation.

Access to Health Services

Access to basic health services are a frequent concern of remote, rural ASM communities and the GMP-target communities are no exception. Poor health generates a vicious cycle – when spouses or family members are infirmed and their capacity to work is diminished, a "healthy" family member must work harder to pay for normal living expenses in

addition to health costs. Ill health of a family member may initially drive people into ASM and - as arduous work coupled with inexperience in mining and lack of knowledge about chemical exposures can further exacerbate the potential for injury or illness - the cycle of ill health and poverty is perpetuated. The primary issues with respect to access to medical services are distance and the costs associated with transportation to clinics, followed by the cost of treatment itself.

Despite the presence of health clinics in the Kadoma-Chakari Region, Zimbabwe, most of them are reserved for use by employees of mining companies. For example, the Chakari clinic is reserved for employees of Falcon Gold's Dalny Mine. Other miners and Chakari residents must travel 20 to 40 km to facilities in or near Kadoma, which costs on the order of Z$2000 (US$2.43) for a return trip. The community feels strongly that Falcon Gold has neglected its social obligation to former workers who were retrenched by the mining operation, most of whom are now small scale miners. It is believed that these miners should be given access to the clinic, at least during emergency situations. The majority of cases taken to clinics are not accidents, which reportedly occur infrequently, but are related to cases of malaria and sexually transmitted diseases.

Rwamagasa Village in Tanzania also does not have adequate health services, but is in the process of constructing a village dispensary. Currently, villagers rely on depend on five small privately owned pharmacies in their village and services available in Geita town, mainly a district hospital. Common illnesses in the Geita District are malaria, acute respiratory illness, pneumonia, and typhoid.

In Ingessana District, Sudan, people must walk at least one half of a day to access the nearest available clinic. For serious diseases, residents must travel even farther to the Damazin Hospital, which has been described as a difficult task during the rainy season. The most common afflictions cited by survey respondents are malaria, chest pain, dyspnoea and coughing, as well as fatigue, irritability and depression especially among women. It was observed that many of the miners suffer from eye problems (red eyes, tearing, itching etc.). It should be noted that the respiratory and neuropsychological symptoms reported are also symptoms which can be indicative of mercury toxicity. Lack of health services for childbirth is also a major issue for women. The infant and maternal mortality rates in Sudan are 65/1000 and 550/100,000, respectively (UNDP, 2003).

Health services are also lacking in São Chico and Crepurizinho, Brazil where the only public services in the village are health posts for malaria analysis and treatment, which belong to the National Foundation of Health. In the larger village, Crepurizinho, a health agent is also paid for by the government to provide basic services. Approximately 39% of workers in Crepurizinho reportedly have been sick in the last two months, and almost all (83%) interrupted work due to illness. Around 75% from the people who fell ill sought medical assistance at an average cost of R$160 (US$53) for private treatment. Around 20% have had a work accident and 35% have witnessed fatal accidents.

The Indonesian Government provides a local health center for each district, which services to villages within that district. Therefore, one local health center in Kereng Pangi takes care of the people in Katingan District (included Galangan) and one in Tatelu

provides health services to Dimembe District (included Talawaan village). The health center in Kereng Pangi is equipped with one doctor, nine nurses and two midwifes, while the health center nearest to Talawaan is supported by three doctors, one dentist, 16 nurses and nine midwifes. The centers are responsible for mother-child care (pregnancy and immunization program), diseases like malaria and tuberculosis and minor accidents. The centres are not sufficiently equipped to treat serious accidents and, in such cases, people must travel to hospitals in Kasongan/Palangkaraya for Galangan Area and Manado for Talawaan area

Of the eight villages surveyed in Lao PDR, only four have a pharmacy and two have a dispensary, which were initially established by aid projects. General health and hygiene standards vary throughout the region and between the surveyed villages. Between 37% and 67% of the sample population of surveyed villages recorded a significant sickness in the previous 12 months. Of the recorded illnesses, malaria was typically the most common, followed by acute respiratory illness and diarrhoea.

Access to Education

Although primary schools are located within walking distance of the GMP-target communities, access to education has been described as inadequate due to issues ranging from a shortage of teachers, lack of secondary schools, absenteeism and early dropout rates, and distance to schools.

High rates of absenteeism and early dropout, as documented in most GMP-target communities, were mainly attributed to the need to use children as an informal source of labour. As children get older, the expectation to undertake mining or various types of informal labour (e.g. tending cattle, farming) increases significantly. This fact is markedly influenced by the lack of secondary schools in all GMP-target communities. In Crepurizinho, Brazil, for instance, 63% of the population has not continued beyond the 4^{th} grade. In Zimbabwe, this is more pronounced in mining families than processing families, as children are less likely to be engaged in processing than mining. Furthermore, most schools in the Kadoma-Chakari region are 2-7 km away from most of the mining sites, which likely hinders participation somewhat. Other issues in many GMP-target communities, such as drug abuse and alcoholism, also influence attendance. In order to reduce absenteeism, local government in Rwamagasa village, Tanzania, has gone so far as to impose by-laws which restrict child labour in ASM.

In the Blue Nile region in Sudan, where there are 161 primary schools, most of them have a shortage of classroom buildings, teacher's houses, latrines and furniture. Furthermore, the teacher to pupil ratio is 1:95, which is considerably worse then the national standard ratio of 1:45. The shortage of teachers in the Region is partly attributed to irregular payment of the salaries (most teachers are paid every three to six months) combined with an elevated death rate – currently the death rate is one teacher per month.

In Brazil, as in most places, the presence of village schools is strongly dependent on government support. In Crepurizinho, the single elementary school offers grades one to six and is staffed by six employees (four teachers, a caretaker and a cook). In 2003, 146

students enrolled, less than half that enrolled in 2002 (300 students). The school building, formerly a hospital, was purchased and donated by a city councillor. The school has its own power generator, whose fuel is provided by the local government. In São Chico, the village school was constructed in January 2003 but ceased operation in June 2003 for reasons unknown.

As in other GMP-target communities, the Lao PDR villages have primary schools, but secondary education is only accessible at considerable distances from home, in this case district centers. Thus, it is not surprising that only 5% of the population had completed Costs related to secondary school include transportation costs, accommodation and schooling fees.

Gender barriers have also been shown to influence girls' access to education. Almost all of the Ingessana people interviewed indicated that the education of women is not important, as illustrated by an illiteracy rate in women of 99%. In some countries, girls are removed from school at the onset of puberty, due to mistrust of male teachers and students and fears of unwanted pregnancies (Unesco, 2000). When girls do enter the school system, they tend to be responsible for considerably more extracurricular chores than boys, thereby resulting in a longer hours worked daily and less attention to homework.

Diet

In most GMP-target communities, carbohydrates represent the bulk of the household diet. Protein sources, such as meat and fish, are less frequently consumed as they typically must be purchased, are prized for their value or are scarcely available. The exceptions are communities where fish are locally available, such as Lao PDR. When protein is not available on site, frequency of protein consumption can be correlated with income. For example, processors in Talawaan, Indonesia, consume meat far more frequently than their mining counterparts. In some locations, such as in Brazil, Sudan and Lao PDR, mining families keep a small garden or plot of land which provides a source of vegetables or additional grains. Due to the lack of protein in most diets, combined with the lack of fruits and vegetables in some communities, malnutrition could be prevalent in some GMP-target communities, evidence of which was observed in Tanzania. Based on surveys conducted in GMP-target communities, diets of community residents have been summarized in Table Six.

Table Six: Diet

Region or community	Carbohydrates	Protein	Vegetables or Fruit	Other
Sao Chico and Crepurizinho Brazil	- rice (daily) - cassava flour (daily)	- Beef (weekly to daily) - Fish (infrequently)	- depends on seasonal availability (supplemented by gardens)	- beans (daily)
Talawaan and Galangan Indonesia	- rice (daily) - instant noodles (bi-weekly)	- Fish (daily by processors; tri-weekly miners)	- vegetables (daily in Galangan only)	- milk (weekly) - eggs (rarely)
Lao PDR Villages (8)	- rice (daily)	- Fish (daily) - Chicken (rarely)	- vegetables (forest collected and grown in small gardens) - fruit (2-7 times per week)	- eggs (2-7 times per week)
Ingessana District Sudan	- sorghum, maize-based staple (presumed)	- Meat – rarely (only 7% eat daily) - Fish – very rarely	- rarely (dried vegetables)	- milk (67% drink daily)
Rwamagasa Village Tanzania	- Not known (presumed to be a staple)	- Meat - Fish - Chicken All 1-2 times/week	- Vegetables (50% eat daily) - Fruit (27% eat daily)	- beans, milk (~1 time/d) - eggs (less than 1 time/wk)
Kadoma-Chakari Region Zimbabwe	- Sadza (corn meal porridge twice daily)	- Meat (1-2 times per week) - Fish (occasionally when in season)	- Vegetables (twice daily)	- beans, eggs and milk (1-2 times per week)

Sources of Energy

Many GMP-target communities are not located on the national power grids or electricity costs are prohibitive, thus, residents rely on other sources of energy, exclusively or in combination. Sources of energy include the whole spectrum of possible alternatives, from firewood to a range of petroleum products through to electricity. In Geita district, Tanzania, the main sources of energy for both industrial and domestic use are firewood, petroleum products and electricity. People in Rwamagasa village depend mainly on firewood, charcoal and kerosene for cooking and lighting purposes, and petrol and diesel to run milling machines and crushers. Firewood and charcoal are the only sources of energy in the Ingessana Hills. Firewood and charcoal, and to a lesser extent kerosene, is used for cooking in Indonesia, while generators and kerosene are mainly used for lighting by processors and miners, respectively. In Lao PDR, three of the eight villages surveyed (Ban Houay Lo, Ban Latthahai and Ban Pak-Ou) are supplied with electricity.

Information and Communication

The sources of information that are available to and used by area residents must be ascertained to effectively design and implement an intervention. In the majority of GMP-target communities, radio is a key means of obtaining information and should be considered for information dissemination campaigns. In Zimbabwe, radio repair is cited one of the main source of subsidiary livelihoods in the Kadoma-Chakari Region. In

Rwamagasa Village, Tanzania, despite the extensive telecommunication and cellular telephone services available in the Geita District (through the Tanzania Telecommunication Company Limited and Vodacom/Celtel, respectively), telephone service is not available. Most residents rely on a number of available radio stations within the country (e.g. Radio Tanzania and Radio Free Africa). Furthermore, residents of Rwamagasa must travel to Geita town in order to access the Tanzania Posts office, which offers services such as mailing letters, parcels and financial transfers, both locally and internationally.

Transistor radios are the only means of information in the Ingessana District of Sudan. The nearest telephone service is found in Dairang village some 30 km away. The Gam chromite mine and Police stations in Bau and Gam have wireless facilities.

In the Brazilian communities, access to telecommunication services varies between the two communities. Since 2002, Crepurizinho has had a telephone line (Telemar), which provides service to a number of public and residential telephones. Alternately, São Chico, is still not integrated into the telephone network, but one residence offers telephone services (rural mobile) that works as a public telephone (costing ~US$1/min for a conventional telephone call). In both communities, 65-80% of residents obtain information from the radio and, in Crepurizinho, television.

In Talawaan, Indonesia, radio is the most favoured source of information for the mining community, as reported by 64% of the miners and 61 % of the processors. Other sources of information are newspapers, television, and/or community leaders, while 17% of miners and processors indicate that they do not have any source of information. In Galangan, general information is obtained from a combination of community leaders, radio, television and newspapers. Interestingly, almost 60% of miners and processors claim that their main source of information is community leaders. Radio is also a source of information for 18% of respondents, but an additional 18 % of miners claim that they have no source of information.

MINING ACTIVITIES

The duration of mining, number of those impacted by or reliant on the activity, type of practices employed, division of labour and arrangements by which people sell products and purchase goods, all directly influence the extent and nature of environmental and human health impacts and provide a broader indication of the impacts and benefits of ASM. These characteristics vary somewhat between the GMP-target communities, however, some very critical similarities suggest that inherent knowledge and instinct that may drive these commonalities across cultures and continents.

Mining practices in GMP-target communities ranged from low-tech methods, as in the Sudan, to somewhat mechanized operations, as observed in some Brazilian mine sites. Often, a clear division of labour is evident, which is gender-based (e.g. men as diggers, women as panners), class-based or, in some cases, racially-based. In most communities, miners were clearly differentiated from millers/processors, with the latter earning often much higher incomes.

In all locations, mining is a time and labour intensive activity. For example, in Rwamagasa Village, Tanzania, the majority of miners spend 12 hours per day processing gold. However, one-quarter of miners spend 24 hours in the pits. The Ingessana people in Sudan spend on average eight hours per day at the mine site doing work they contend is tedious and high-risk. In Talawaan, miners work in shifts throughout 24 hours a day; on average the miners and the processors work more than 6 hours a day. The minimum they work is 4 hours a day and the miners work a maximum of 12 hours while the processors work a maximum of 8 hours a day. The specifics of mining practices in each of the GMP-target communities are summarized as follows.

History of Participation in Mining

Other than the Brazilian and Laotian communities, which are marked by several decades of ASM, most artisanal mining activities in GMP-target communities commenced in the late-1990's (Table Seven). Although the cause for participation in mining is frequently linked to poverty and the lack of viable alternatives, other reasons relate to family tradition, recommendations from friends and displacement or downsizing from a local or regional large scale mining company.

In Zimbabwe, small-scale artisanal gold mining is a growing sector whose effects cannot be ignored. In the Kadoma-Chakari area, this sector has significantly increased since the 1990's. This can be correlated to the downscaling of mining operations of the main mines in the area, which include the Dalny Mine owned by Falcon Gold and the Cam & Motor, Brompton and Patchway Mines, all owned by Rio Tinto Zimbabwe. This left the greater community in the area unemployed who, as a means of survival, are now engaged in small-scale gold mining.

According to a survey conducted in Rwamagasa Village, Tanzania, most respondents commenced mining activities around 1972, but this commenced in other mine sites. The mining activities gained momentum at Rwamagasa from 1998 onwards. Due to the transient nature of the miners, it is difficult to ascertain the exact numbers of miners, but it is believed to be increasing, mainly as many miners displaced by the Geita Gold Mining Company (GGM), based in Geita Town, opted to invest money from compensation packages into small-scale mining in Rwamagasa.

Most people in Rwamagasa initially became involved in mining due to economic hardship (21%), while others had done so on the advice of friends (18%). Remaining respondents (78%) are continuing on the family tradition, having inherited the activity from their parents, or grew up in a community without other economic alternatives. Of the people interviewed, 98% have lived there for more than five years. Most of them come from different parts of the country, but mainly from a neighboring village in Nyarugusu ward (11%), which is another prominent mining area in Geita district.

Although artisanal mining of both primary and secondary (e.g. alluvial) ore bodies has taken place throughout the Blue Nile Region since the 17th century, mining in the Inganassa District in Sudan has reportedly only taken place since 1996, when gold was discovered about 80 miles southwest of Damazin town, the capital of the Region.

Chromium (chromite) mining is also important to the region. Since 1996, a significant number of people have been attracted to the region, especially those displaced by the civil war, such as the Dawalla ethnic group. Now there are more than 800 families practicing alluvial and hard rock artisanal gold mining in Ingessana district. Most of the mining skills of the Ingessana people, including the use of mercury in gold amalgamation, were learned from the Dawalla who were displaced by civil war from the historic Kurmuk gold mining district. In addition to gold mining, the Dawalla are also the main buyers of gold from the Ingessana. They provide them with mercury and also supply them with their daily needs (sugar, bread, soap, tea, coffee, etc.), likely in exchange for gold.

The communities of São Chico and Crepurizinho, Brazil both have much longer mining histories than most other GMP-communities, with discoveries occurring in 1963 and 1962, respectively. Presumably, the first areas exploited were those closest to the village, which was built around the airplane landing strip. With the opening of the Transgarimpeira in the mid-1980's, site access was no longer limited to air, which contributed greatly to the viability of mining during the 90's. With exploitation of primary deposits in the late 1990's, São Chico reached top production in 1999-2001, producing about two tons of gold in a single work front (Montanha) and attracting up to 5,000 people. Since then, mining activities have subsided considerably at São Chico. Crepurizinho, which was discovered around the same time, relied on boat access until 1974, when a landing strip was constructed, followed by road access with construction of the Transgarimpeira Highway. Crepurizinho achieved top production between 1983 and 1990, producing around 350-400 kg of gold per month. At that time, 10,000 people lived at the village. In the 90's, the discovery of new ore bodies heated the region's economy again, albeit not at the same level as those observed in the eighties.

Mining activities in Talawaan area began in 1998 following the discovery of gold in 1997 by PT Tambang Tondano Nusajaya a joint venture owned by Aurora Gold Ltd. (85%) and PT Austindo Mining Corporation (15%). The mining area is closed to some villages, despite the fact that the area was previously used for agriculture by adjacent communities. A severe economic crisis in 1998, combined with the delayed start-up of company operations, led to the shift of many local residents into gold mining. Rumours about the presence of gold in the area of Tatelu resulted in invasion of the company's mine sites and a rapid growth of ASM activities in Wasian, Taelu, Tatelu Rondor, Tatelu Warukapas, Talawaan, Kolongan, and Tetey villages. Between July 2000 and June 2004, the number of processing units grew from about 250 to 400 units, the majority of which were constructed near the Talawaan River and its tributaries. With this rapid growth, the negative perceptions from local inhabitants reliant on fisheries and fruit plantations also escalated. The government subsequently tried to control mining by restricting activities to no closer than 700 meters from the rivers or springs and the villages, but these efforts were to no avail.

With mining activities extending back to the 1970's, Galangan has experienced a much longer mining history than Talawaan. Mining began with simple panning along rivers until the introduction and widespread use of mercury in the late 1980s changed practices. This was followed by the use of hydraulic monitors which are employed today. Between 1986 and 1999, PT Ampalit Mas Perdhana, an Australia - Indonesia mining company,

operated on ~25% of a 200 km^2 protected area. During this time, widespread ASM in the region caused extensive environmental devastation resulting in the delayed closure of the PT Ampalit Mas Perdhana's mine. During the height of activities, more than 5000 miners worked in the region but today this number has decreased to about 500 units of 4-6 workers (~2500 miners). In Galangan, Kalimantan, alluvial gold mining provides employment for about 2500 people working in 500 separate units or sites. The place lies approximately 100 km from the Palangkaraya city, the capital of Central Kalimantan. The nearest urban area is Kereng Pangi, a small town with around 10,000 inhabitants that is located 7 km from Galangan.

Table Seven: Participation in Mining Activities

Region or community	Duration of Miners Participation in ASM (Average)	Length of Time in GMP-target Community (Average)	Commencement of Mining in GMP-target Community
Sao Chico Crepurizinho Brazil	- 16 yrs - 18.5 yrs	- 8.1 yrs - 6.5 yrs	- 1963 - 1962 (both escalated in the 1980's)
Talawaan Galangan Indonesia	- < 5 yrs - < 5 yrs	- na (likely same as duration in mining)	- 1998 - 1980
Lao PDR Villages (8)	- na	- na	- between 1978 and 1985 (ave 1982)
Ingessana District Sudan	- 7 years (since 1996)	- traditional land (Inganassa) - less than 7 years (Dawalla)	- 1996
Rwamagasa Village Tanzania	- almost 30 yrs	- more than 5 yrs	- 1998
Kadoma-Chakari Region Zimbabwe	- na	- na	- Since 1990's (major escalation)

In most of the surveyed villages in Lao PDR, ASM began in the mid-1970s, and was a widespread activity by 1980. ASM is typically carried out at the family level involving men, women and children who are generally lacking in technical skills and sophisticated equipment. The extent of mining activities and the resultant gold outputs vary among villages in the region, with between 45% and 96% of the surveyed households having at least one household member engaged in the activity.

Mining Practices

Kadoma-Chakari District

The Kadoma mining district, together with the Kwe Kwe mining district, have for many years been the leading gold producers in Zimbabwe. Large mines include Dalny, Patchway, Golden Valley, Globe and Phoenix, Cam and Motor, Gaika, Brompton and Indarama. There are more than one hundred small gold mines in the area, which have also been productive at different times throughout the twentieth century. Less than half of these have accounted for over 90% of the production. Most of the large mines ceased

gold production more than two decades ago. Collectively, the mines in this area have produced hundreds of tonnes of gold over the years. All mining activities in the Kadoma area are situated within commercial and resettlement agricultural areas, which are among the leading producers of cotton and maize in the country.

It is estimated that over 20,000 small-scale miners are active within the Kadoma-Chakari region. Less than 5,000 of these are involved in reef mining and reprocessing of tailings, while the bulk are alluvial gold panners. The latter accounts for more than 75% of the mercury consumption in the region. Most of this mining activity is concentrated in the vicinity of three large-scale mines (Dalny, Golden Valley and Patchway Mines). In Zimbabwe, it is estimated that there are between 300,000 and 400,000 artisanal gold miners sustaining the livelihoods of at least two million people (Maponga and Ngorima, 2003).

There are three categories of people engaged in the ASM in the Kadoma-Chakari district:

1. *Miners* who excavate and extract semi-weathered gold ore and take this for processing at custom milling centers. There are about 3,000 to 5,000 people involved in this activity. The miners extract ore from narrow shafts as deep as 50 m and hire trucks once a month to take the extracted material to the milling centers. Miners do not process the ore. The monthly production of one team of miners (3 to 4 people) is reported to be around 20 tonnes, which is enough to produce 200 g of gold (if gold recovery of 10 g/tonne of ore processed is assumed).
2. *Millers* who work in the milling centers where the ore is milled and concentrated for the miners. There are probably about 1,000 to 2,000 people in over 70 milling sites in the Kadoma-Chakari region. Millers have more capital and education than the majority of miners and panners.
3. *Panners* are individuals who concentrate alluvial gold by panning the gravels in creeks and rivers or re-processing tailings from former industrial mining operations. They represent the majority of individuals extracting gold. The 15,000 to 25,000 panners in the Kadoma-Chakari region are highly nomadic.

Miners and Millers:

In the Kadoma-Chakari region, ore extraction is highly manual, involving digging with basic tools, i.e. picks, shovels, hammers and chisels. Where reef mining occurs, shallow shafts and tunnels are excavated. Workers and ore are hoisted by windlass and bucket. In most instances, steps are dug into shaft walls as people dig deeper (up to 30m) to enable the ore to be moved up by shovels. However, in a few cases vertical shafts are dug, with miners being sent down using a bucket and rope from a hand-operated winch. In such cases, digging can go to depths beyond 30m. The ore is transported by road to the nearest functional stamp or ball mill. Due to the manual nature of the work and hardness of the parent rock, digging is primarily undertaken by men. When women are involved in the digging of the ore, this usually is at shallow depths (2-5m). Protective clothing (gloves, coveralls, safety boots, helmets) are generally not worn by any of the miners.

Ore is sent to nearby, independently-operated stamp or ball mills for crushing. Some miners bring their ore from as far as 70km away. The average load brought to the mill by a miner is roughly 5 tonnes of ore per month. This yields between 5-15 g of gold

depending on the quality and source of the ore. The technology employed by the customized, electrically-powered milling centres varies with some using wet stamp mills (3 or 5 stamps) with a capacity of 0.2 to 0.5 tonne/h and others using jaw crushers followed by grinding with ball mills with a capacity of between 0.7 to 2 tonnes/h. Miners prefer milling centers with stamp mills as they believe that ball mills retain part of the gold in the internal liners. Stamp mills seem to be more accepted in the region – likely because the entire process is clearly visible to miners - despite their relative inefficiency in grinding and the longer grinding time.

The centers charge between Z$ 10,000 (US$2.86) to Z$ 14,000 (US$4) per hour of grinding and concentration depending on the hardness of the ore. Using stamp mills, hard rocks take 5 hours/tonne to be ground and concentrated, whereas soft ores take 1.8 hours/tonne. The stamp mills operate with water and the pulp is discharged through a 48 or 65 mesh screen (0.3 to 0.2 mm). The pulp (about 20% solids) discharged by mills subsequently undergoes whole ore amalgamation using copper-amalgam plates or a concentration process.

When concentration follows milling instead of whole ore amalgamation, this generally involves use of a Zimbabwean centrifuge (known as a “speedy bowl”). The centrifuges used in Kadoma are 120° cones, like a “batea” with riffles on the wall. They are copies of the Knudsen Concentrator developed decades ago in California. There is no fluidization to promote mineral exchange in the concentrate bed and it is likely that gold is lost once the riffles are full. The efficiency of the speedy bowl can be improved by introducing a rake to scratch the concentrate bed. These centrifuges cost a fraction of the price (between US$ 1000 and 2000) of the available centrifugal concentrators (e.g. Knelson and Falcon concentrators) and local equipment manufacturers have the technical capacity to develop any type of equipment suitable for small-scale miners. About 30 to 33 kg of gravity concentrate is produced from a batch of 15 to 20 tonnes of ore.

Some miners add three teaspoons (~ 45g/teaspoon) of mercury into the centrifuges. This poor practice “flours” part of the mercury, which results in its loss with tailings. Millers wash out the concentrate from the centrifuge and give it to miners who perform the amalgamation in barrels, adding 400 to 800 g of mercury to amalgamate 30 to 33 kg of concentrate. Miners can add what they want to amalgamation barrels, including soap, acids, etc. Many miners add sodium cyanide tablets into the amalgamation barrels to clean the gold surface and improve amalgamation. In many cases the pH of the pulp is below 7 facilitating the release of hydrogen cyanide gas, unbeknownst to the miners. In many cases, miners prefer to conduct amalgamation manually (i.e not using barrels) adding mercury to pans or plastic trays. The gold is then recovered on-site by evaporating mercury by burning.

When whole ore amalgamation is conducted in lieu of centrifuges, ground ore is mixed with mercury on the copper plate and, once amalgamation has taken place, the amalgam is scraped off and squeezed in a cloth to remove unused mercury, which is then collected in a container for re-use. The gold is then recovered on-site by volatilizing mercury by burning. As miners often bring their own mercury and add it at various stages of the process, estimates of mercury consumption are difficult to establish. In two operations,

the amount of gold produced in each milling center using centrifuges was around 2 to 3 kg/month with between 2 and 3 kg/month of mercury being lost in the process. This results in a ratio Hg_{lost}:$Au_{produced}$ = 1. When copper plates are used to amalgamate the whole ground ore, the miners estimate that twice as much mercury is lost. Assuming that all 70 milling centers in the region are losing between 2 and 4 kg of Hg /mo, on the order of 1.7 to 3.4 tonnes/a of mercury is being emitted to the environment in the Kadoma-Chakari region from the milling operations alone.

In both the stamp mill and ball mill processes, most of the gold is retained in the primary tailings; thus, the millers apply vat-cyanidation to extract this remaining gold. Miners receive no compensation for the gold extracted from tailings. Most centers have 5 to 10 cyanidation tanks to process tailings. About 20 to 70 tonnes of tailings from the gravity circuit and the amalgamation process are added to cement tanks to be leached with 18 kg of sodium cyanide (NaCN) per tank. No pH monitoring is done. Operators add 50 kg of calcium hydroxide ($Ca(OH)_2$) per tank and wait an average of 6 days to complete the leaching step. Since no forced aeration is provided to the pulp, the leaching process is slow and sometimes it takes 10 to 15 days, depending on the gold concentration and accessibility of the cyanide solution to the gold in the ore particles. The solution percolates through the ore and it is recovered at the bottom of the tanks where a sand-filtering process is set up. The gold-laden cyanide solution is analyzed using a $SnCl_2$ colorimetric method to check the gold content. The solution passes through 6 PVC columns lined with activated charcoal to remove gold from the cyanide solution. As the millers do not have access to the stripping technique, they remove the first three columns and send them to a company in Kwe Kwe which performs the elution (gold stripping) process. This company charges Z$ 175,000 (US$50) per load to strip gold from the carbon and deposit it by electro-winning onto iron wool. The millers do not have any control over the amount of gold in the carbon given to the elution company. The millers dissolve the iron wool with hydrochloric or sulphuric acid to obtain pure gold. The final tailings from vat-leaching, which contain residual cyanide, are carelessly disposed of although some centers re-vegetate the dump sites.

Panners:
Gold panners in the Kadoma-Chakari area work in local rivers and streams, especially the Muzvezve River, or pan tailings from former mining company operations (sometimes with their authorization). Panners are typically from other regions or countries and are frequently harassed by local police. In the dry season, panners often divert the Muzvezve River and excavate the gravels to concentrate gold in improvised sluice boxes (locally known as 'James Tables', processing 1.5 to 2 tonnes of material per day and recovering 0.2 to 0.4 g of gold (and losing an equal amount of mercury). Gravel is excavated manually and washed in rudimentary home-made screens (a sheet of iron with ½ inch holes) to remove coarse pebbles. The fines pass through the sluice boxes lined with pieces of clothes. After several runs, the cloth is washed in an excavated pool located in or outside the river. Subsequent amalgamation in plastic trays yields a small amount of amalgam which is burnt in an open wood fire. Amalgamation tailings are discarded along river margins.

Rwamagasa, Tanzania

In Geita district in Tanzania, two types of gold mining are conducted: small-scale artisanal mining, which is undertaken in 250 small scale mining sites that average 8.3 hectares in size, and large-scale mining, which includes a degree of research (i.e. reserve estimation). The majority of artisanal miners are in Nyamtondo, Rwamagasa, Mgusu, Nyarugusu and Nyakagwe wards, with majority of the residents of Rwamagasa being primarily involved in mining. Most artisanal miners do not own claims and, as a general rule, 30-50% of the ore dug out of the ground is given to the claim holder every three days. In Rwamagasa, many of the enterprises are family affairs and participation in this livelihood is passed down through generations.

In Rwamagasa, miners dig shafts or pits to reach the paying reef or weathered lateritic material. Using picks and shovels, they dig as deep as 10 to 15 meters to reach the gold-bearing lateritic material where fragmented quartz and greenstone rocks are encountered. Semi-weathered to hard rock ores are also mined using shafts with depths between 50-100 m to reach the main gold-bearing layer crossing the area, known as the Blue Reef. After using explosives to break the hard ore rock, rock is dug out with a pick and shovel and then hoisted to the surface using locally fabricated wooden winches or a hoisting winch.

Usually the miners grind an ore fragment to test it for visible gold. A drum of water (200 liters) is used to wash the crushed test ore. The drum is supplied at a cost of 200 TShs (US$ 0.18) by local traders or business (known as *"Makota")*. The drum owner claims any gold left at the bottom of the drum. On the basis of results from test gold washing, the miner decides to continue mining or move on to another site.

Usually the ore is taken home to be manually crushed either by members of the family or labourers. After the ore is crushed to a certain size, the ore is taken to the ball mill. Alternately, miners sell ore to *Makota* or transport it themselves to milling centres, which are located in residential areas or on the bank of the Isingile River. *Makota* buy the ore on the spot based on a visual estimate and quick tests of the gold content, a practice which enables the miners to continue their activities, but may not yield a fair price for the ore. The ore is sun-dried or stacked over wood and leaf fires in order to dry it. Ore is transported to milling centres using trucks, tractors, donkeys, bicycles, and humans, especially children and women. Approximately 40 kg of ore is transported in polyethylene bags to the milling centres where different individuals are hired to crush the ore manually before it is fed into ball mills for final crushing into powder.

The ball mills, which use cast or forged steel balls, are usually composed of a modified tractor with a wheel hub connected to the ball mill or are powered by diesel generators. In one operation visited, the ball charge was: 200 balls of ∅6.46cm, 800 balls of ∅4.86cm, and 200 balls of ∅3.24cm while in another it was: 30 balls of ∅9.70cm, 570 balls of ∅4.86cm, and 600 balls of ∅3.24cm. These loads occupied more than the 35-40% of the mill volume, which is what is normally recommended for dry grinding to provide mill volume for air sweeping and dust control (Rowland, 2000). In some cases, the balls mills are poorly sealed and dust is emitted throughout the process. Finely ground ore is discharged through a perforated steel plate in the side of the mill. As water scarcity is not

an issue, it is unclear why wet grinding is not used, but it may be attributed to the fact that it is easier to handle and bag dry ore. This is a significant issue as each individual in the processing centers, including the mill owner, is paid by the amount of ore bags processed (Table Eight). It has been observed that wet grinding may result in some improvements as it would reduce dust in the air and require at least 30% less power than dry grinding.

Table Eight: Payment for Individuals to Perform Various Processing Operations[1]

Activity	Amount paid/kg to an individual	kg processed per day
hand crushing	TSh$ 14 – 19 (US$ 0.0125-0.0175)	80 - 100
grinding	TSh $ 85 – 99 (US$ 0.075 - 0.0875)	soft: 640-720 [2] medium: 400-480 hard: 320-400
sluicing	TSh$ 14 - 28 (US$ 0.0125 to 0.025)	400 - 600
amalgamation	TSh 112 (US$ 0.10)[3]	10 - 20

1. A typical extraction production of a team of miners is of 800 kg/week of hardrock and 8,000 kg/week of weathered (soft) ore. In many cases the payment is with ore bags instead of cash
2. grinding rates depends on ore hardness
3. manual amalgamation: per kg of *concentrate* processed

After crushing, the material is washed in nearby man-made ponds over a 4-6 m wooden pan covered with sackcloth or sisal cloth (i.e. a sluice box). The dry ground ore is discharged into a feeding box and water is carefully added using buckets. The sisal clothes are very coarse and it seems to be adequate for coarse-to-medium-size gold particles but not fine gold particles. The cloth is then washed clean in a bucket in which the concentrate settles and is recovered for subsequent amalgamation. Tailings are left at the site (and may subsequently be reprocessed) or simply dumped into the river.

Mercury, which is typically provided by the owners of the mills at a cost of ~TSh 22,500 (US$ 20/kg), is added to the concentrate in a pan and thoroughly pressed and mixed by hand for up to 2 hours. Panning is conducted until all that remains is the final amalgam product with the remaining mercury and tailings usually being discharged into a concrete tank for reprocessing (which is usually undertaken by women) or directly into the river. The amalgam is then burned in open air to release mercury, leaving gold. Burning usually takes place in locally made charcoal stoves or bonfires. In most of the operations, the visible amount of remaining mercury in the gold doré seems to be higher than 20%. The miners put the amalgam in a polishing shoe tin and this into a bonfire covered with charcoal. Men, women and children often watch the burning process throughout. Gold is most commonly purchased by *Makota* for about TSh 10,000 (~US$ 8.85) per gram or if it is of good quality.

Ingessana Hills, Sudan

Gold mining has taken place in the southern Blue Nile region for more than 100 years, but was only initiated within the Ingessana Hills in the past decade. This transition can mainly be attributed to the displaced Dawalla people, whose resettlement and subsequent need for livelihoods led to prospecting and discovery of gold, first in a quartz vein near to Gugub village. Although the Dawalla continue to be regarded as the most skilled in

artisanal mining in the region (and control mainly aspects of mining supply and trade), the indigenous Ingessana have also learned artisanal gold mining skills, significantly increasing the incomes of both groups to ~S.D.20000 (US$80) per month. The Dawalla contend that they learned how to use mercury to recover gold in the North of Sudan. Thus, it is likely that when peace is achieved in the South, Dawalla miners will bring back amalgamation to homeland as a "new" technique learned in Gugub.

Gold mining in the sites around Gugub is practiced without legal titles. Given the adverse situation created by the civil strife in the 1990's, the Government tried to legalize gold mining in the southern Blue Nile and elsewhere by granting special licenses. In 1998, the government granted a 10 km^2 concession covering the Gugub sites to a national company, while protecting the rights of artisanal gold miners to continue mine alluvial gold in the area. The legal conditions, however, strictly approved of *only* alluvial mining. A few mill owners attempted to introduce hammer mills in Gugub in 1997-1998 but authorities quickly drove them out.

Gugub and the surroundings communities comprise about six major artisanal gold mining sites. At present, Khor Gidad and Khor Neiwi, ~7 km north and 5 km northeast of Gugub, are the main sites where more than 800 artisanal gold miners produce gold from both alluvial and illuvial deposits. Primary gold is found in three sites including the noteworthy discovery of gold-rich quartz vein in September 2003 near Khor Gidad. With information of the strike, ~500 miners rushed into the area from Gugub and elsewhere and extracted 56 kilograms of gold in a single week. Currently the number of miners in Gugub and in nearby villages, Taga and Khor Gam, is ~800 and ~300 artisanal miners, respectively. More than 50% of the workforce is comprised of women and, in the rainy season, this can reach as much as 90% as men go planting.

In the Ingessana District, both hard rock and soft rock mining takes place. Gold mining and extraction in the Gugub site of the Ingessana Hills is a labour intensive job at all stages. Once a rich gold occurrence is located, hundreds of artisanal gold mining families start wildcat pitting the hillside or stream terraces until the gold-rich horizons are reached; usually at depths between 5 and 20 m. Men and women dig shafts of approximately 5 meters in depth using axes, picks, and shovels. In the case of hard rock deposits, 5 kg sledge hammers and chisels are also used. Usually two or three people work in one shaft simultaneously. One miner works underground with a torch or dry battery, while another hauls 20-25kg of ore using a bucket and a rope. A third miner empties the bucket into a plastic or wooden container and carries it to a site where further processing takes place.

Ore is most frequently carried home where it is crushed and ground, mainly by women, until very fine. In some cases grinding is undertaken using a steel mortar or grindstone. Each individual produces no more than 10 kg of ground material per day. Using a wooden pan (~5 kg capacity) and some water, panning of the ground ore is conducted by women. When only fine grains remain, visible gold is removed by hand picking. Then mercury is added to the concentrate and amalgamation takes place in a frying pan. This is subsequently burnt, often in the presence of several family members who await the results in anticipation. As gold is sometimes visible in certain rock types, many Ingessana

believe hard rock mining to be more viable than soft rock or alluvial mining. Gold is subsequently sold to a trader, who deducts the cost of additional mercury purchased. The gold trader, who spends the day travelling from site to site, usually pays either in cash or goods (e.g. sugar, tea, flour, soap etc.).

Alluvial-type gold, which is mainly panned by women and old men, goes directly to the market without further processing. The efficiency of panning using traditional wooden pan is ~50%. In sites like Khor Gidad north of Gugub, water for panning is scarce in mid summer. Ingessana women bring water from shallow wells ~2 km away to sell. Water is transported by balancing a pair of 4-gallon plastic containers on their shoulder using a stick. Two containers (eight gallons) of water cost SD 50 (US$ 0.20).

On average, the amount of gold ore extracted from a pit per miner per day is about 0.5 tonnes of alluvium and 20-30 kilograms of rock. A gram of gold produced from alluvium through panning has a higher price in the local market (US$9-9.5) compared to a gram of gold extracted from hard rocks through amalgamation (US$ 6- 6.5). Gold trade both in Gugub village and in the mining sites is handled by about 5 local merchants and a number of traders/middlemen from El Damazin. Gold is weighed using locally-made balances, which are not always well-calibrated. Only one dealer at Khor Gidad has a small digital balance.

Final purification and melting of gold is traditionally performed by goldsmiths; the end dealers in the production cycle. The goldsmiths are also the major mercury suppliers because they have access to big gold markets in Khartoum and Omdurman. Gugub merchants buy mercury from dealers at ~US$29/kg. It is also known that part of the produced artisanal gold goes to neighbouring Ethiopia. There is a longstanding legal and illegal border trade of coffee, livestock, and gold; particularly in the Kurmuk and Qeissan boarder districts.

In Gugub sites and elsewhere within southern Blue Nile region, tailings produced from gold extraction activities are usually disposed of near the mining/panning extraction site. Conspicuous tailings heaps are a common picture wherever there are alluvial or primary artisanal gold mining activities. Around Gugub, it is estimated that about 400,000-500,000 cubic meters of tailings/waste has accumulated along the banks of Khor Gidad, Khor Neiwi, and other localized areas. Seasonal run-off washes a portion of the tailings into stream beds leading to siltation of rivers that extends as far as the Blue Nile.

São Chico and Crepurizinho, Brazil

In São Chico, Brazil, six out of seven work sites are active, with a total of 69 people directly involved in the extraction (59 miners/workers and 10 cooks). Secondary gold mining and – in all active sites but one – reprocessing of tailings takes place. Tailings are reworked up to three times, sometimes not even covering extraction costs. Work teams are composed of three people (one in the "spurt end", one on the hose, one assistant), with 30% of the gold produced given to them. Extraction through reprocessing of tailings eliminates several of the work stages which traditionally require a lot of effort (root cutting, river bank clearance).

In Crepurizinho, the situation is much different. Since 1998, miners from Poconé, Brazil have brought gold processing plants to the region. Using mills, centrifugal concentrators and amalgamation containers, these plants are able to process an average of 25 to 30 cubic meters of auriferous material daily, staffed by two shifts of six people. Typically, mining takes place using pairs of machines with three team members. In Crepurizinho, most alluvial deposits have been exploited and mining is mainly focused on primary gold deposits. In this case, amalgamation usually takes place at mills. Cyanidation is now also conducted in at least two locations. Mining in Crepurizinho is now facing an unprecedented problem: a lack of work force. At least two visited work fronts were paralysed due to lack of workers. In July 2003, around 60 pairs of machines and 15 shafts were active in the region. This translates to a population of about 350 people working directly in these sites (300 gold miners and 50 cooks) and a monthly production of about 50 kg gold.

Gold extraction methods vary with the degree of mechanization. The most rudimentary method involves passing gold-bearing material over a rockers or sluice boxes lined with carpets or other fibrous materials. Heavier particles retained in the textiles are subjected to mercury amalgamation to separate gold from other materials. Excess mercury is separated from the amalgam by twisting a piece of cloth around the amalgam. Once the amalgam is obtained, it is burned in open air using a blowtorch.

The dredge or raft method is a more mechanized but fairly simple technique that enables processing of material from the bottom of a water body. Both dredges and rafts use hydraulically controlled suction pumps although they differ in that a raft employs a diver who manually directs the suction of the material to be brought to the concentration equipment. Typically, a dredge or raft is mounted on two wooden boats or two iron tubes of about six meters in length with mounted diesel motors (from 40 to 65 hp). The raft is covered with nylon protection and manoeuvres rivers by 15 hp outboard boat motors. The larger horse-powered engines power a centrifugal pump mounted onto two hoses with diameters between 4 and 6 inches. In one of the submerged hoses, a scraper, which is locally known as *abacaxi* (pineapple), provides suction of gravel or mineralized sediment. The pumped slurry is brought to the surface and passed through a screen which removes the cobbles and coarse gravel and discharges the fine fraction into a sluice box lined with carpet and riffles to concentrate coarse particles, including gold.

The final concentrate is obtained after washing the carpet. At this point, mercury is added into the sluice boxes, and the material is collected in an amalgamation drum, where additional mercury is added. The excess mercury is filtered in the same way that was described above and the amalgam is burned with a blowtorch in a bowl.

On-land, alluvial and colluvial ore is mined using a *chupadeira* or *par de máquina*, the local names for hydraulic monitors. The mining sequence is as follows: first, the vegetation is cleared, second, the *barranco* (the geological material) is fluidized with two high pressure water hoses (2 to 3 inch diameter); and third, the slurry is sent to the upper box with a screen where the finer material goes to a riffled sluice box lined with carpet covered retains gold. Typically, a second hose provides water to adjust the dilution of the

slurry. Gold is recovered from the carpeted or riffled sluices and processed using the same procedure as described for the dredges and rafts.

The hammer mill method was initiated in the Tapajós following the discovery of primary gold in a quartz vein. Using this method, material is excavated and the ore transported to the hammer mill. The mill then grinds the ore to -1mm which is then transferred to the sluice box and processed in accordance with the previous methods.

In all aforementioned methods, tailings are discharged into rivers or pits close to mining activities. Reprocessing of tailings is often undertaken by local unemployed people. More recently, however, cyanidation of tailings has been reported. In this process, cyanide is added to a 20 to 30% solids pulp made up of old tailings (or primary ore concentrates) in a tank. The tank is stirred for a 10 to 12 hour cycle (presumably with the addition of $Ca(OH)_2$ of $CaCl_2$ to adjust the pH). After this time, the liquid is separated from the solids and subjected to precipitation using zinc powder or adsorption on activated charcoal. In a variation of this method, cyanide solution is passed over gold-bearing material and left out for some days, the overflowing liquid being treated as above.

Talawaan and Galangan, Indonesia

Gold mining in Talawaan, Indonesia is carried out in teams of approximately 10 men in pits under a constructed shelter. In addition to digging, manual crushing of ore taken from the pit is also conducted under the shelter. Bags of crudely-crushed ore are sent to sluicing locations nearby where 8 to 12 generator-powered tumblers crush the ore into fine sand that is later combined with mercury by the tumbler operators. Water for sluicing is taken from the adjacent creeks and rivers. After the process of amalgamation, the amalgam is then burned either at the site where sluicing takes place, in mills, or gold shops. Some miners use retorts while others burn the amalgam using a blow torch under a fumehood. Recently, operations in Talawaan have become more sophisticated; employing mechanical crushers in mills and heavy machinery and other equipment in tunnel development (e.g. mine cars for ore transport). Some mine or processor owners have also temporarily employed engineers and other technical personnel.

Mining in Talawaan also involves extraction of primary ore through underground mining. The artisanal miners begin with narrow vertical shafts (1m x 1m) and tunnels to maximum depths of 30m. These shafts and tunnels are dug by hand and openings are supported with wooden bars and wooden boards. The ore is excavated manually using traditional tools such as shovels, hoes, crow bars, etc. and loaded into containers (e.g. buckets), which are drawn up to the surface using a pulley. At the surface, they are packed in sacks and transported to a processing plant using a cart drawn by oxen or buffalo.

At processing plants, which are located within villages near dryland rice fields, the ore is sun dried and crushed manually using hammers or other traditional tools. Currently, some processing plants are using homemade mechanical crushers to replace manual workers. After the crushing process, approximately 30 – 40 kg of the crushed ore is fed into ball mills for grinding. Water and hard rocks are added into the ball mill in order to break down the ore into fine particles, typically over a 3-4 hour period. After this period, the

mill is turned off briefly and 1 kg of mercury is added. The ball mill is rotated again for half an hour during which time a portion of the fine gold amalgamates with mercury. Water is then passed through the ball mill in order to pour out the slurry. All of the milled ore is then dumped into a pond, where the heavy metal alloy settles to the bottom. Approximately 600 grams per kilogram of mercury is recovered while the remainder is lost with the fine fraction of clay material that is poured into the drainages and during amalgam decomposition.

The amalgamated mercury is separated from the slurry through the panning process. The amalgam is squeezed through a fine woven cloth to separate the excess of mercury from the amalgam. This amalgam is burned in a clay crucible to vaporize the mercury. In some cases, borax is added to remove impurities in the final products.

A portion of the miners in Talawaan store their amalgamation tailing in sacks and sell it to cyanidation plants. In these plants, tailings are placed in agitation tanks with water until it consists of ~40% solids. The slurry is agitated in order to settle the excess mercury. According to one plant owner, for 20 tonnes of tailing, about 300 – 500 grams of mercury can be recovered using this method. After this separation, tailings are leached in a tank with 100 – 200 mg/l NaCN at pH 10 – 11 adjusted with lime. Aeration of the slurry is carried out using a simple air compressor. After 3 batches, 100–150 kg of charcoal is added to the leaching tank in order to adsorb gold. The charcoal is separated by filtering, then the charcoal is burned in open air, leaving gold. Residual mercury also adsorbs to the charcoal and is released during burning thereby contaminating operators. It should be noted that the cyanide tailings contain soluble mercury-cyanide complexes which are discharges into the environment and are susceptible to bacterial methylation of mercury.

In Galangan, mining is carried out in sandy areas among gravel and rocks where man-made pits are spread throughout. In each pit, a group of 4–5 men work in teams where gold-containing sand and gravel is sprayed with a high-pressure water jet powered by a diesel pump (i.e. hydraulic monitoring). The slurry is then pumped into a sluice box (~4 m long) which is riffled and/or lined with carpet to maximize retention of gold particles. The gold-bearing sand is cleaned from the sluice boxes and panned to obtain a cleaner gold concentrate. Pulp containing 20 kg of concentrate is placed in a pail and ~200g mercury is added and stirred by hand. After several minutes, pulp is strained using a cotton cloth to remove excess mercury and produce the gold amalgam. The amalgam is then sold to gold shops in either in Galangan or Kereng Pangi. Miners typically conduct smelting activities in their huts, but have also observed burning amalgam in restaurants and shops.

Lao PDR

Mining in the Lao PDR villages is seasonal with the peak of activities being between January and April towards the end of the dry season. During this period, the water level is low; therefore, it is convenient for artisanal gold miners to extract alluvial sediment. It is estimated that over 3,000 people are involved in artisanal gold mining in the region with more than 500 living in the project area. In the GMP-target villages, more than half of the

population is engaged in ASM. Although these miners do not have legal permits all mining activities in Lao PDR are required by Mining Law to be registered.

In most of the villages surveyed, mining is a family operation located close to villages with men conducting digging using shovels and chisels while women and children transport the ore to bowls and sluice boards, pan the ore and perform the gold extraction processes (which are usually carried out in the home).

The mining process on the Nam Ou River and Mekong River typically involves the following:

- *Site preparation and removal of overburden*: Riverbanks are cleared of vegetation and large debris and the ground is checked for structural instability.
- *Digging pits:* Men excavate alluvial material mainly using simple tools, such as shovels, buckets and long chisels.
- *Transfer of the ore to sluice boxes:* Ore is mixed with water to form slurry to be processed in sluice boxes which are lined with a thick sack cloth to retain gold and other dense particles. The sack lining is then removed and washed in a bowl where a secondary concentration occurs. The final concentrate consists of dark, heavy particles.
- *Panning and sieving of the ore:* Women and children pan and sieve the remaining material on the riverbank using head pans, shallow bowls and sieves made from fishing nets. In this way the ore is disaggregated further leaving a gold and heavy mineral concentrate (e.g. magnetite).
- *Amalgamation (in villages that use mercury)*: Mercury is added to the gold/heavy mineral concentrate.
- *Heating and blowing (in villages that <u>do not</u> use mercury)*: In villages where mercury is not used, following the panning and sieving process, the gold/heavy mineral concentrate is heated to dry the concentrate and the heavy minerals are separated with a gentle blowing. In some villages using the heating and blowing process, a small portion of mercury is used to amalgamate the residual gold from the heavy mineral part. In these cases, a very small volume of mercury is used.
- *Removing excess mercury*: The mercury-gold amalgam is then squeezed through a fine cloth, and the excess mercury is collected for re-use.
- *Heating and mercury evaporation:* The amalgam is heated and mercury evaporated above the stove. To collect the mercury from the amalgam, the miner places a bowl and bamboo tube in the vertical position around the amalgam. As the amalgam is burned, evaporated mercury condenses on the walls of the interior of the bamboo tube. Condensed mercury is subsequently removed with a chicken feather and re-used. Mercury is reactivated for reuse by adding lime juice to remove impurities. Amalgam decomposition does not typically occur daily but is stored until a suitable quantity is accumulated. Depending on the village and gold content of the alluvial ore, this might be on weekly or monthly basis. Women and children typically carry out this process in the home.
- *Gold sale*: Gold is sold directly to buyers who visit the villages once a week during the mining season. The gold buyers typically come from Luang Prabang and afterwards they sell the gold to larger dealers or jewellers. Depending on its purity,

between US$ 2.8 and US$ 3.3 are paid for one Hun of gold (approximately 0.39 grams). This is US$ 7.18 to US$ 8.46/g or at least US$ 100/oz less than the official gold price. When gold contains a large quantity of mercury or other impurities, the gold buyer will conduct further refining prior to resale. The gold buyers also provide the villagers with mercury.

In the Lao PDR GMP-target villages, there are some variations in the methods described. For instance, in villages along the Mekong River, mercury is traditionally added at the panning stage to form an amalgam with alluvial gold particles. Conversely, villages on the Nam Ou River do not generally use mercury to form an amalgam with the gold, but rather use gravity separation by heating the sieved and panned material and periodically blowing away the concentrate surrounding the gold particles. This difference is largely attributed to the presence of coarse gold in some locations which can effectively be recovered without amalgamation. Underwater excavations also takes place in some locations wherein divers transport the ore to large floating rafts where women and children perform sieving and panning. Underwater excavation employs more specialized tools such as long-handled poles and chisels and weighted buckets.

Gold Production

The generation of comparable gold production data in GMP-target communities is complicated by the hesitancy of miners to report their income, combined with variability in production calculation methods. Some assessments base gold production on average gold grade and estimated mill throughput, while others collect government data on declared production (typically a largely underreported amount), and others infer productivity from the gold production of individual miners coupled with the estimated number of miners. Thus, it is evident that the information presented in Table Nine on gold production in GMP-target communities should be applied with some caution.

The difficulty in establishing gold production is exemplified by the situation in Tanzania. In the Geita district, the past decades have been marked by wide fluctuations in the numbers of gold miners which, coupled with the migratory nature of miners, has complicated estimates of participation. In addition, the amount of undeclared gold is expected to be high, with a major portion of gold being smuggled to countries and markets offering a better price. In 1991, when the Government was buying gold through the National Bank, the reported production was around 617 kg. This quantity decreased substantially to around 2 kg/year between 1993 and 1996 when the bank stopped buying gold. When a private company, Meremeta, started buying gold in the Geita region, gold production increased from 2 kg in 1996 to 420 kg in 1998. Recently, the company ceased its activities and the reported gold production declined again to 153 kg in 2001 and 14.1 kg in 2002. Currently, there are a number of individual gold buyers in the region and they do not report the exact amount of gold purchased from miners.

Table Nine: Gold Production

Region or community	Purchase Price of Gold[1] US $ per gram	Annual Gold Production (kg)
Brazil - Crepurizinho - Sao Chico	7.3	400 – 500 13 - 14
Indonesia - Talawaan - Galangan	7.5 – 8.5	300 250
Ingessana District Sudan	6 – 6.5 (amalgamation) 9 - 9.5 (alluvial)	240
Lao PDR Villages (8)	7.18 – 8.46	4.8
Rwamagasa Village Tanzania	10.40	153 (2001)[3] 14 (2002)[3]
Kadoma-Chakari Region Zimbabwe	8.75	3300 – 5500

1. International Price of Gold ~US$12.89 per gram (based on US$400/oz)
2. Price offered by government
3. Based on production reported to government.
4. Typical purchase price offered by local gold dealers.
5. Based on mercury lost to gold produced ration and reported mercury consumption.

Frequently, miners sell their gold well below the market value. In the case of Zimbabwe where the government sets the price and purchases gold from miners, the price is still below that of the international market. In many cases, miners cannot afford to travel to cities to obtain better prices. This has likely contributed to the widespread smuggling of gold out of the country.

Proximity of Residences to Mining Areas

The proximity of mining and processing activities to residential areas speaks directly to the environmental and human health risks experienced by community residents, as well as the amount of labour and energy expended in transporting materials and/or travelling to the work site.

Almost all of the mill workers in Kadoma-Chakari region of Zimbabwe live with their families in the vicinity of the mill sites, with the greatest distance to work being 500m. Since most of the burning of the amalgam is done at the mill site, such household are vulnerable to fumes coming from the burning of the amalgam to extract the gold. Also highly vulnerable are the miners who do the actual burning of the amalgam. Since most miners travel 2- 15 km to the mill sites, their households are less vulnerable. Exceptions include the Tix mining community, where some of the milling, concentration and amalgamation (involving rich ore) is done within the compounds.

The distance from the mine pits to the residences of those interviewed in Rwamagasa Village ranges from 0.75 km to 3 km, with 33% living with half a kilometer from the mine pits, 33% within one kilometer, 6% two kilometers and 21% living three kilometers or more from the mine pits. Although these pits are outside of their residential areas, gold processing is done on their housing compounds.

In the case of the Brazilian communities, townsites are typically used as a logistical base for work sites from which miners obtain supplies and sometimes reside (although they often stay at informal camps at sites). Crepurizinho, for instance, serves a number of operations within a 10 km radius.

In Talawaan, the average distance of the miner's homes to the sites is 391 meters with a maximum of 2 kilometers and the average distance of the collector's homes is 4.6 kilometers with a maximum of 25 kilometers from the mining sites. Of all, most of the mining community lives at the distance of 100 meters from the mining sites.

Property Ownership

In most GMP-target communities, people own equipment and/or tools, household items, and in rare cases, their homes. However, very rarely do miners own the land on which they mine or the rights to mine it. An example is Rwamagasa Village, Tanzania, where miners do have access to gold pits, but they do not own or have mining licenses. Only 9% actually own gold pits. About 10% own livestock and 52% have access to houses, while 30% own houses that are permanent structures, i.e., houses constructed of concrete blocks with a corrugated iron roof. Very few respondents own milling equipments or motor vehicles. The other items which they control, and have access to, are radios, bicycles, sewing machines, etc. In Ingessana District, Sudan, miners also have access to mine sites, but do not actually own property or have mining licenses. About 75% own a few cows and goats, while 99% of the miners own manual, locally made mining equipment i.e. shovels, digging tools, wooden plates and pans. Land ownership and the right to mine represents a key issue with respect to mitigating the environmental and social impacts of ASM and imparting long term benefits to the local community.

Mining Related Concerns and Issues voiced by Miners

Miners and residents of GMP-target communities were asked to express their primary issues and concerns with respect to ASM. These issues are summarized as follows:

- General lack of equipment and proper tools;
- Lack of pumps to drain flooded pits and workings;
- Lack of access to capital to purchase equipment;
- Lack of fair and reliable gold market. In some cases, the seasonal availability of gold markets is also problematic. Gold buyers, who often also provide goods and services (e.g. transportation, mercury, food, tools) and deduct these expenses from the price of gold, are often considered to be unfair, retaining an inflated percentage of profits;
- Lack of mining rights/land ownership;
- Inadequate methods to ascertain and validate the quality of gold;
- Theft;
- Invasion of mine sites;
- Lack of water for gold cleaning (in some locations);
- Mining accidents and poor community health exacerbated by inadequate health services;

- High processing costs. Many feel much economic benefit is lost to millers and therefore would like to purchase milling equipment. Access to capital or credit is main impediment to this; and
- Miners would like to also receive profits received by millers from processing of tailings through cyanidation. Also, some miners expressed interest in operating cyanidation plants, funding permitted.

Other issues believed to be problematic include lack of knowledge about geology; insufficient skills in mine methods and planning; poor management and financial skills; inadequate legal framework; and lack of support from government. Environmental and human health impacts of ASM are also recognized by miners as an important issue (particularly when queried about this); however, this seems to be considered somewhat secondarily to economic and labour related issues. One of the suggestions put forth by the Tanzanian Women's Mining Association (TAWOMA) to address these and environmental and health issues, was the establishment of a "Mining Kit", which would essentially be a mobile processing unit which could move from one miner to another. The unit would be housed in a truck and would include equipment for crushing, milling and gold recovery equipment.

ENVIRONMENTAL AND HUMAN HEALTH RISKS

Many environmental and human health issues associated with ASM can be found in each of the GMP-target communities. The extent of the impact on the local environment and community residents, as well as the water bodies that extend beyond local boundaries, is largely reliant on the mining methods employed and scale of production. As environmental health is intimately linked with human health, the ramifications of mining practices are discussed on an issue-by-issue basis. Environmental health and human health issues identified in the socio-economic assessments of the communities include the following:

- occupational and environmental exposure to mercury;
- use of cyanide (in some GMP-target communities);
- nitric acid exposure (in Zimbabwe);
- lack of basic sanitation and poor water quality;
- exposure to dust from breaking, crushing and grinding rock;
- deforestation;
- land degradation;
- ground instability (causing landslides and shaft collapses);
- siltation of watercourses due to tailings discharge and/or riverbank erosion;
- widespread disease and illness (tuberculosis, malaria, hepatitis, sexually transmitted diseases including HIV/AIDS, etc.);
- violence, domestic and otherwise;
- alcohol and drug abuse; and
- injuries and accidents.

One of the critical human health issues, as evidenced by the unsafe mining practices commonly employed in the GMP-target communities, relates to the misuse of mercury.

Major issues related to mercury and some of the other environment challenges identified in the GMP-target communities are described further below.

Mercury

In all GMP-target communities, mercury was identified as a significant health concern. This particularly relates to occupation exposure to mercury (i.e. through inhalation), although environmental exposure (i.e. through ingestion of contaminated fish) also gives cause for concern. The nature and extent of the impacts of mercury on environmental and human health is a function of the volume of mercury used and subsequently emitted into the environment and the nature of its use.

The amount of mercury discharged into the environment has not been quantitatively determined in the GMP-target communities; however, the amount emitted likely correlates closely to the mercury consumed by gold mining. The price of mercury and its consumption varies significantly between the GMP-target communities, as shown in Table Ten. Estimates concerning mercury use and the ratio of mercury lost to gold produced are difficult to establish as, in many project communities, information was typically obtained in only one or two sites. The highest reported ratio of mercury lost to gold produced (60 to 90:1) and correspondingly high mercury consumption observed in Talawaan, Indonesia can be attributed to the fact that 1kg of mercury is added to the ball mill for every 30-40 kg of ore. In all locations the price of mercury was several times higher than the international price of ~US $4/kg. The price of mercury in Lao PDR (US$ 75 – 87.60 per kg) is among the highest in the world and inevitably influences the amount of mercury used in mining.

Table Ten: Mercury Use

GMP Site		Mercury Price[1] (US$/kg)	Hg_{lost}:$Au_{produced}$	Hg lost (tonnes/a)
Brazil	- São Chico	15 - 30	1.5 - 3	0.03 - 0.04
	- Crepurizinho	15 - 30	1 - 1.5	0.3 – 0.5
Indonesia	- Galangan	9 - 12	1 – 2.5	0.3 – 0.5
	- Talawaan	10 - 15	60 – 90	20 - 30
Lao PDR	- Luang Prabang	75 - 88	0.3 - 0.5	0.001 - 0.002
Sudan	- Blue Nile	25 - 30	1 - 1.5	0.3 - 0.4
Tanzania	- Rwamagasa[2]	18 - 25	1 - 1.5	0.03 - 0.06
Zimbabwe	- Kadoma[3]	12 - 25(*)	1 - 3	3 - 5

1. International Price of Mercury ~US$4/kg.
2. Based on mercury use at the Blue Reef Mine only.
3. Based on consumption at mills and by panners

As observed in the description of mining methods, mercury amalgamation practices are – with slight exceptions - generally quite similar between the GMP-target communities. Main differences are attributed to the price of mercury (as observed in low-mercury consuming Lao PDR), the use of mercury in ball mills and centrifuge barrels (as is the practice in Talawaan and the Kadoma-Chakari region, respectively) and the application of retort-like devices.

In the Kadoma-Chakari region of Zimbabwe, the fate of mercury in amalgamation tailings that are subsequently subjected to cyanidation was identified as a cause for concern. Mercury is known to form strong complexes with cyanide, resulting in mobilization of a portion of mercury in solution (i.e. discharged with effluent) and a portion being retained in tailings. As mercury-cyanide complexes are highly soluble, this may contribute to the downstream transport of mercury in aquatic systems. It has further been suggested that mercury in this form may be more susceptible to transformation to biologically available forms (i.e. methylmercury), thereby enhancing the potential for its incorporation into the food chain. Cyanidation of amalgamation tailings was observed not only in Zimbabwe, but in the GMP-target communities in Brazil and Indonesia.

In cases where cyanidation is not conducted, mercury tailings are often discharged into local drainages, crude impoundments or sometimes old pits. In aquatic systems, mercury associated with tailings may be transformed to biologically available forms (i.e. methylmercury) which biomagnify up trophic levels of the food chain, often resulting in elevated mercury concentrations in the tissues of carnivorous fish, in particular. In the case of Gugub in the Sudan, where 300-400 kg of mercury is released annual to the environment, the village is located at a relatively high elevation (~800m a.s.l.) on a rugged hillside. As a result, soil erosion during the rainy season (600-800 mm) carries mercury discharged from huts into local creeks and downstream into the Roseries reservoir. Built in 1965, the Roseries dam reservoir covers an area of ~410 km^2 and is a major source of fish in the region. Commercial fishing is an established business in El Damazin and Roseries districts. The annual catch from the reservoir (~30,000 tonnes/a) supplies the fish markets of the Blue Nile, Gazira, and Khartoum states. Nile perch (*Lates niloticus*) and Tilabia (*T.nilotica)* are the major species consumed. Although it is not the primary cause of methylmercury in fish, the mercury introduced from mining would exacerbate the high levels anticipated in fish due to the "impoundment effect". A widely recognized phenomenon, high mercury levels in fish from reservoirs are linked to the presence of conditions which facilitate the methylation of background levels of mercury in vegetation and soils. The mechanisms driving the transformation of mercury to methylmercury are associated with flooding of reservoirs and subsequent degradation of organic matter.

Atmospheric deposition of mercury released from burning also represents a hazard for residents living in proximity to these activities. In Gugub village in Sudan, for instance, most of the gold shops are located along the village's main road (~300 m long) and comprise a geographic center, being surrounded by miners' huts. As the temperatures at which mercury is burned is relatively low (for instance, in comparison to forest fires), the mercury does not rise substantially and is mainly deposited locally.

Mercury and Human Health

Occupational hazards associated with mercury are mainly related to inhalation of mercury during amalgam decomposition and refining and, to a lesser extent, handling of mercury during the amalgamation process. Typically, this is conducted with no protection (e.g. gloves) and often takes place in the home. In all countries but Brazil, it was observed that women and children are predominantly engaged in amalgamation in the

home. Other than in the Lao PDR communities, where a crude bamboo mercury condenser was used by some miners, mercury is most often burnt in open air.

In Rwamagasa Village in Tanzania, miners who have been engaged in amalgamation or smelting for many years have exhibited symptoms of severe mercury intoxication including ataxia, tremor and movement disorders (e.g. difficulty walking). Although in-depth studies of mercury toxicity have not yet been conducted, preliminary assessments of mining practices and the amounts used suggest that mercury toxicity from inhalation of vapours may be widespread in the GMP-target communities. For instance, women engaged in amalgam decomposition in the Ingessana Hills district have reported respiratory problems, irritability and depression, and eye problems (itching, redness), which may be indicative of mercury toxicity.

In many cases, children handle mercury with their bare hands during amalgamation and observe the amalgam decomposition process, often indoors. Typically, children are engaged in mining from the age of about 10 years, but often accompany their parents to work prior to this. Mercury can cause severe neurological damage to the developing brain, resulting in effects ranging from learning disabilities to varying degrees of mental retardation.

Awareness of Mercury Risks

Awareness of the environmental and human health risks associated with mercury use varied widely between and within the GMP-target communities. The level of awareness was lowest in Lao PDR, where only 2% of households surveyed indicated any awareness of the risks associated with mercury. Awareness was greatest in Brazil, Tanzania and Zimbabwe (75%, 60% and 61% of respondents, respectively), while the percentage of respondents with some mercury awareness in Sudan was 25% and Indonesia ranged from 55% (Talawaan) to 15% (Galangan). Respondents who indicated some level of awareness could not accurately name symptoms or effects of exposure.

In Zimbabwe, more than half the miners (61%) surveyed in the Kadoma-Chakari Region had some prior knowledge of the harmful effects of using mercury, yet few (15%) used any sort of protection against it, often handled it with bare hands.

Similar circumstances were observed in Tanzania, where at least 60% of the respondents in Rwamagasa Village are aware of the environmental hazards caused by the use of mercury. As many as 25% of them described some of the effects of mercury exposure, such as general body weakness and strokes. Sources of information on mercury include the Resident Mining Officer (50%), UNIDO 6%, Mass Media 15%, other people 16%, books and seminar 9%, VETA (10%) and their friends (6%). A substantial number of women have little or no awareness about mercury, the apparent reason being that most individuals or groups who bring outside information predominantly talk with the leaders and the male miners. Quite often, recipients of information do not share new found knowledge with other villagers.

Table Eleven: Potential Mercury Exposure Pathways

Mercury Exposure Pathway	Kadoma-Chakari Region (ZIM)	Rwamagasa Village (TANZ)	Ingessana District (SUD)	Sao Chico and Crepurzinh (BR)	Talawaan and Galangan (IND)	ASM Villages (LAO PDR)
Occupational Exposure						
Inhalation through amalgam burning - miners	Y	Y	Y	Y	Y	Y
Inhalation through amalgam burning - processors	Y	Y	Y	Y	Y	Y
Inhalation through handling or spills	Y	Y	Y	Y	Y	Y
Community Exposure						
Potential for Hg to accumulate in aquatic food chains[1]	na	na	N	Y	Y	Y
Ingestion of fish (important protein source)	N	Y	N	N	Y	Y
Potential for Hg to accumulate in terrestrial food chains[2]	na	Y	Y	na	na	na
Children – play with mercury	na	Y	Y	na	na	na
Inhalation – In-home amalgamation	Y	na	Y	na	Y	Y
Inhalation - Homes in close proximity to amalgamation sites	Y	N	Y	Y	Y	Y/N

Y = YES (PATHWAY OBSERVED OR PROBABLE); N= NO (PATHWAY NOT OBSERVED); na = INFO NOT AVAILABLE

1. Mercury believed or observed to be discharged into water courses during mining
2. Although some communities have expressed concern about contamination of crops by mercury, uptake of inorganic mercury (the form discharged by miners), is expected to be low. A more detailed risk assessment should be conducted to ascertain risks from consumption of terrestrial and aquatic food sources.

With respect to new methods of reducing mercury exposure, most respondents are willing to adopt a new technology (94%) and receive training through demonstration (78%). There was concern, however, that gold dealers (*Makota*) who provide mercury would resist efforts to reduce mercury consumption. Thus, it was suggested that education should also focus on those who supply the mercury.

The level of awareness is even lower in the Ingessana District of Sudan. Almost 75% of people interviewed say that mercury poses no risk, while 17% indicate they have heard mercury causes some problems, but they cannot identify what these health problems are. It was widely stated that there are no problems in obtaining mercury any time it is needed and in some cases it is given for free (contingent on gold being sold to them in exchange). Little or no information about mercury has been made available to the people of Ingessana District. When researchers informed the Ingessana that mercury can pose some hazards, miners were sceptical, stating that they have been mining for a long time and have not seen symptoms of toxicity. As most of the Ingessana are illiterate, observation and word of mouth are key means of communicating information.

When queried about the risks associated with mercury in Brazil, approximately 75% of respondents believed information concerning mercury risks is prejudicial. Despite this, miners could not correctly identify risks, their knowledge being limited to the identification of the smoke from gold burning as dangerous. Interestingly, approximately 80% of miners in São Chico had undertaken amalgam decomposition through burning. Approximately 13% identified mercury pollution as one of the environmental impacts of mining and a just over half of the workers (52%) think that mining is harmful to the environment. Most miners received information about mercury from TV or radio (65%) or friends (22%).

In Talawaan, Indonesia, awareness of the health effect of mercury among the miners varies. Nearly half of them (45%) admit that they do not know how mercury could harm their health. The rest have only scant knowledge that mercury may afflict the respiratory system, skin, eyes, or cause other symptoms. Approximately half of the miners (42 %) state they do not know that mercury has any effect on the environment, while the other half of respondents indicated that mercury may damage plants, water, soil, and fish. In Galangan, miners claim that they do not face any problems from mercury exposure. Awareness of the danger of mercury seems very low among the miners, with 87 % unaware of dangers of mercury on health and 83 % unaware of the effect of mercury on environment. The remaining miners have some awareness that mercury may cause ill-effects to people and may damage plants and pollute water. Sources of information about mercury, however limited in terms of effectiveness, comes from brochures, friends, personal experience, TV, nurses, and the village authority

In the Lao PDR villages surveyed, household awareness of the potential health implications of exposure to mercury is invariably low, with only 4 households (13%) in Ban Thinhông, and 1 household (4%) in Ban Houay Koh indicating a general perception of risk. All lacked any data or specific information on what hazards mercury may pose or how these hazards could be avoided. The lack of hazard awareness has important implications for future capacity building and educational campaigns.

Other Environmental and Health Issues

Forest Clearing

One of the most visible impacts of mining relates to the land clearing that generally precedes mining activities. For instance, in Galangan, Indonesia, the rainforest has essentially been reduced to a desert landscape. This results in a loss of vegetation and, as a consequence, increased erosion and siltation. Camourze et al (2001) highlighted the importance of erosion in carrying natural mercury bound to old-intensively weathered soils to Amazonian aquatic systems. The authors stressed that this is a more important source of mercury for the entire Amazonian environment than any other source, including ASM activities; however, this is expected to be of greater concern with increasing proximity to mine sites, where erosion of mercury rich soils and tailings exacerbates this situation.

In some cases, deforestation also provides timber for the construction of shelters, underground supports, to fashion pans, as firewood and for other domestic uses, as was observed in Zimbabwe and Tanzania. In Rwamagasa Village, the miners obtain timber to stabilize pits from the nearby forest reserve. Prior to mining, the forest covered the entire region. At the current rate of forest extraction, it is anticipated that the forest will be entirely depleted within the next five years.

Deforestation can significantly impact the health of families, due to the importance of the forest in terms of fuelwood and as sources of food and medicine. As well, deforestation by burning sites for clearing can release mercury retained in vegetation into the atmosphere.

Mining Pits

The environmental degradation associated with the excavation of large volumes of material can affect groundwater (when the water table is encountered), as well as adjacent drainages. Waste material is often heaped in close proximity to pits. This creates a source of silt which can be eroded by rainfall, clogging nearby rivers as noted in Brazil and Tanzania. In Gugub Village, Sudan, an estimated 400,000 to – 500,000 tonnes of waste and tailings are piled near pits. Siltation is exacerbated with increasing proximity to rivers, as was observed in the Lao PDR villages where alluvial mining of riverbeds takes place. In other circumstances, when tailings are backfilled into depleted pits, contamination of groundwater may occur.

In a number of the GMP-target communities, pits have been described as veritable "death traps." In Rwamagasa Village, Tanzania, non-paying abandoned pits reach depths between 2 and 20 metres. In Galangan, Indonesia, depths typically range from 5 to 50 metres. Animals and people walking in the area, particularly at night, have been known to fall into pits and drown during wet season when pits are covered by thick grasses. A similar hazard was documented in Ingessana Hills, Sudan.

Water Quality and Quantity

Impacts of mining on water quality and quantity primarily include siltation of rivers, contamination of ground or surface water and diversion of rivers.

In Zimbabwe, alluvial gold panning activities along the Muzvezve River involves digging up of the river channel and its banks, paleo-channels and their floodplains, as well as surface trenching using picks and shovels, all of which mobilizes extensive volumes of silt. Hydraulic monitoring in São Chico and Crepurizinho, Brazil, as well as in Galangan, Talawaan, have been major sources of silt to adjacent river systems. The effects of siltation from *garimpos* in Brazil can be observed as far as 300-500 km downstream in the Tapajós River. In some cases, siltation of the river may create dams resulting in flooding and diversion of rivers. Siltation can reduce the transmission and storage capacities of rivers and dams and is believed to play a major role in the frequency and magnitude of flooding affecting Mozambique, Zimbabwe and South Africa. Further, silt reduces light penetration and clogs the gills of fish, making water inhospitable for a host of aquatic organisms. Siltation may also render the water undrinkable for grazing animals

and humans. In both cases, siltation may reduce access to an often much-needed source of food and water.

Some miners intentionally divert rivers for use in mining. For example, in the dry season, panners in Kadoma-Chakari region may divert the river to areas where they are actively working in order to process alluvial material in sluice boxes. As well, it is not uncommon for miners to construct water impoundments by diverting rivers in mine sites for use in hydraulic monitoring or processing, both of which require substantial volumes of water.

The dependence on the use of large amounts of water in mining operations dictates that they be located as close to water sources as possible, and in some cases immediately adjacent to the water sources. As a consequence, water bodies may be subject to contamination, not only from mercury used in processing, but also from domestic wastes, such as sewage, detergents and other chemicals. Often these same water bodies are also used for domestic purposes, including consumption, which represents a major human health concern.

Dust and Noise

Being in proximity to mining and milling operations typically equates to exposure to dust and noise. The situation in Rwamagasa Village, Tanzania exemplifies this situation where, in the mills in particular, the noise level is extremely high as no water is used in the ball mills – repeated or chronic exposure to these conditions could cause hearing impairment. In Tanzania it was also observed that operators and people around the mill are exposed to a significant amount of dust, largely due to the use of dry grinding. In Rwamagasa Village, milling centres are located within the residential areas and, when in operation, can be heard throughout the community.

In addition to dust generated in mechanized mills (as observed in Talawaan, Rwamagasa, Kadoma-Chakari and the Brazilian communities), manual rock crushing can also create dust and may be a health hazard in confined environments, such as in underground mine shafts or in people's homes. Inhalation of fine, crystalline silica dust, which is generated from breaking and crushing rock, can result in silicosis. Silicosis is an incurable lung disease that kills thousands annually (WHO, 2000). Conditions resulting from silicosis include emphysema, lung fibrosis and silica-tuberculosis.

Other Health Issues

The rapid sprouting of overnight settlements at newly discovered gold deposits leads to rapid 'urbanisation' in the form of ad hoc settlements that not only result in deforestation and other land disturbances, but also social ills associated with unplanned settlements. These vices include alcohol and drug abuse, prostitution, land-use conflicts with local communities, water pollution, and disease outbreaks.

Frequently, infrastructure is lacking, as is characterized by inadequate drinking water and sanitation systems, poor housing and limited access to health services. Observed health issues include infectious diseases, such as diarrhoea, typhoid and parasitism, and poverty-related ailments, such as malnutrition. In Rwamagasa Village, malaria, tuberculosis, and

sexually transmitted diseases including HIV/AIDS are the dominant causes of morbidity and mortality. Other issues include accidents associated with equipment or unstable pits or underground workings. In the Indonesian communities, shaft or pit collapses occur between 2 and 5 times per year.

In the Ingessana Hills district of Sudan, reported complaints range from urinary tract complications, chest and respiratory problems, eye problems, fatigue, stomach problems, and recurrent malaria. In Talawaan and Galangan, residents reported frequent diarrhoea and malaria, as well as asthma, pneumonia, skin diseases, upper respiratory infectious are other important diseases in the both areas. In the Brazilian communities, dengue fever was also documents.

GENDER ISSUES

Women occupy a number of roles in GMP-target communities, ranging from positions as miners, often being responsible for gold processing, to other functions in the household and community. In communities where women undertake ore grinding and subsequent gold recovery through amalgamation, this is often conducted in the presence of children in the home and in the absence of any protective measures. Women are, therefore, often at equal or greater risk from occupational exposure to mercury. Socio-economic surveys conducted in GMP-target communities indicate that women tend to be much less aware of the hazards of mercury than their male counterparts and have not been empowered to make informed decisions about their practices and the impacts on the health of themselves and their families. In addition to educational campaigns targeting women involved in amalgamation, as spouses of miners, women can also play a key role in advocating better amalgamation practices to their partners. Further, as women are predominantly responsible for provision of food, and children and pregnant women are vulnerable to methylmercury, the form predominantly found in fish, strategies to reduce mercury exposure through consumption should also target women.

Roles of Women in Mining

Identification of gender issues was a requisite component of the socio-economic assessments conducted in the GMP-target communities. The extent of women's participation in mining these communities varies considerably, with the greatest participation in areas where the whole family is engaged in mining. Women make up only 11% of all the miners interviewed in the Kadoma-Chakari region of Zimbabwe, while in Brazil women comprise 37% of the labour force. In family operations, as observed Tanzania, Sudan, Lao PDR and Galangan, Indonesia, women presumably make up to 50% of the work force (approximating the ratio of women to men in the communities), although much of their time is divided with other household responsibilities. In all GMP-target communities, regardless of the extent of women's participation in mining, there is a clear gender-based division of labour.

Women working as miners in the Kadoma-Chakari region of Zimbabwe usually are limited to near surface digging (not exceeding 10m), while that done by men could go to depths beyond 30 metres. None of the mill workers were female, which the millers attributed to the manual nature of the work. In some mining households, women were

fully involved in mining processes including digging (100%), carrying the load (100%), mercury amalgamation (70%) and burning of the amalgam (70%).

In Rwamagasa Village, Tanzania, many of the ASM enterprises are family affairs, usually consisting of a husband and wife, children, and relatives. In these cases, it was observed that women often have a markedly increased workload, as mining is conducted in addition to their regular household duties. A women's organization that is active in the region, the Mwanza Women Miners Associations (MWAWOMA), reported that women working as entrepreneurs face specific challenges, including sexual harassment and abusive language.

The Ingessana in Sudan, like many people in Rwamagasa, work in family-based operations, with men responsible for breaking rock and women responsible for grinding, concentration and amalgamation. Women are also predominantly responsible for hauling water, an activity which is both time consuming and laborious. Often, water sources are located more than a 30 minute to one hour walk from the mine site, a situation which is exacerbated through the summer drought. Due to the scarcity of water, women sometimes sell water to other mines in addition to that used by the family. Water is carried using plastic cans tied to strong rope and balanced across women's shoulders.

In the Brazilian GMP communities, where ~50% of the population is comprised of women, men dominate the labour market, occupying 73% of the workforce. Furthermore, women are generally not engaged in mining, with most employment being in service provision roles, acting as cooks, vendors, and sex-trade workers. Furthermore, there is considerable disparity in income. The average male income is around R$538 (US$179), while women earn almost 36% less, averaging R$397 (US$123) per month.

In Galangan, Indonesia, men are predominantly engaged in mining, although women are sometimes responsible for hauling water. The community survey indicated that "fathers take the responsibility of fetching the water" with hauling of water being conducted by fathers 47% of the time. Mothers fetch water 18% of the time, with the remaining transport being undertaken by girls, boys and servants. All miners in the camp-style mining area of Talawaan are male.

In Lao PDR, women and men work in clearly defined roles, with men having the responsibility of alluvium excavation and women (often assisted by one or more children from the family) performing the panning, sieving and gold recovery processes. Men are probably less exposed to mercury directly through mining activities, whereas women and children mining in villages using mercury would potentially be exposed on a daily basis. The tasks of both men and women are essential for the successful recovery of gold and thus both are seen equally to contribute to the gold-derived household income.

Other Roles of Women

In all GMP-target communities, women occupy a wide range of non-mining roles, often related to provision of goods and services (e.g. cooks, shopkeepers) and their typically extensive domestic responsibilities. In the GMP-target communities, women often work as vendors (selling vegetables, sugar, meat, cooking oil and other food stuffs, as well

cigarettes at some mining sites) and providing services (tailoring, cooking, cleaning) for the community and generating much needed income. For example, in Lao PDR, the commercial weaving and textile industry in Ban Thinhông, almost solely employs women and children.

Another role women frequently occupy in ASM communities relates to their position as sex-trade workers. Widespread prostitution coupled with the transient nature of mining activities and lack of education results in high rates of sexually transmitted diseases in this group. In many locales, women function in multiple capacities. For instance, a women working as a panner may also obtain income as a sex trade worker and a cook.

Women also perform the bulk of household work, their domestic responsibilities including childcare, food production, processing, preparation and storage as well as the provision of fuel and water, sanitation, cleaning the house and laundry. Women are often also predominantly responsible for hauling water. In Rwamagasa Village, Tanzania, women haul water 50% of the time, considerably more than men or children. As well, women typically undertake a considerable portion (in some cases the majority) of agricultural duties.

Access to Education and Information

In all GMP-target communities, women have less access to education and information than their male counterparts. In many countries, girls are systematically discriminated against in terms of education, mainly due to family expectations concerning domestic responsibilities, in addition to social and cultural barriers. Some families may be more likely to send boys to school than girls, as has been observed in many other African and South East Asian countries (UNESCO, 2000). In some cases, girls are removed from school at the onset of puberty, due to mistrust of male teachers and students and fears of unwanted pregnancies. When girls do enter the school system, they tend to be responsible for considerably more extracurricular chores than boys, thereby resulting in a longer hours worked daily, less attention paid to homework and increased likelihood to drop out.

Disparate education levels often have an immense impact on the status of women in communities. Almost all Ingessana people interviewed stated that the education of women was not important. Not surprisingly, 99% of women interviewed in Ingessana District are illiterate. In Lao PDR, 26% of women and 13% of men are illiterate. Conversely, women in Galangan, Indonesia, have higher education levels than their spouses. Among the miners, about 65% and 73% of men and women, respectively, obtained primary school education and 28% and 25% attending secondary school.

Differences in access to information can have a significant effect on the risks faced by women and their families and their decisions to employ certain practices. In focus groups conducted in Rwamagasa Village, Tanzania, it became evident that women are less aware of the risks of mercury than their male counterparts. This was attributed to the fact that seminars and information campaigns targeted men in the community.

Women and Decision Making

Decisions about everything from mining practices to household expenditures significantly influence the health and wellbeing of the community. Many studies indicate that the revenue generated by women in artisanal mining contributes more directly to the well-being of households then that of men (Hinton et al, 2003). Specifically, the income generated by women is more likely to be directed towards improving the quality-of-life in the family – *i.e.* through education, food, agriculture, etc. – whereas men tend to spend revenue on gambling, prostitution and alcohol (Hentschel et al., 2001). In addition, when women receive and manage earnings, their economic dependence on men may decline, thereby testing existing gender roles.

Almost without exception, sociological assessments in GMP-target communities indicate that men predominantly control the family income from mining and other activities and make most household decisions. Among the people interviewed at Rwamagasa Village, 60% of males and 40% of females head the household. In the cases where women are heads, they are either single or widowed. The majority of study participants (86%) in Ingessana District, Sudan, indicate that decisions are mainly made by men, while a minority (15%) contend that decisions are made by consensus. In focus groups held with women, a substantial number of participants reported that their husbands have the last say on how the money from gold mining is to be used. It was stated in these groups, which were attended by both Ingessana and Dawalla women, that it is the responsibility of the husband to take care of the whole family. Similarly in Talawaan, decisions concerning expenditures are made by men ~95% of the time, while in Galangan, decisions are made by women 18% of the time, and jointly 30% of the time. Of the surveyed population in Lao PDR, females were the head of the household in an average of 11% of households.

Recommendations: Addressing Gender Issues

Due to their importance in terms of mineral production and provision of vital community services, in conjunction with their susceptibility to poverty, enhancing the role of women in ASM may be an effective means to facilitate positive change in the GMP-target communities. *General* recommendations include the following:

- Increased commitment to gender mainstreaming in government agencies, and appropriate recognition of women in policy frameworks, particularly in relation to land ownership rights.
- Adoption of strategies inclusive of, and accessible to, both women and men, and which support women's participation in political decision-making.
- Elimination of discrimination from educational systems, and provision of support for families sending children to school.
- Formal incorporation of gender issues and the adoption of holistic approaches to artisanal mining communities through technical assistance and community development programmes.
- Promotion of micro-credit and other programmes that provide financing for women.
- Implementation of programs to train women in various aspects of mining, as well as in marketing, management and bookkeeping.
- In-depth research on women's involvement in artisanal mining communities and the differential impact of current practices and technical change on the lives of both women and men.

With respect to the GMP, specific measures to mitigate the impacts of mercury misuse and respond to the barriers that prevent women from fully benefiting from this sector include the following:

- Women should have equal access to training and information programs;
- Educational campaigns should target women in order to mitigate specific health risks, for instance related to environmental mercury exposure;
- Training seminars and disseminated information should seek to sensitize recipients – both women *and* men – as to the importance of gender equity. Key issues should include the importance of education for boys *and* girls and highlight equity in pay for work and equity in decision making;
- Training and information programs should be field tested with women as well as men prior to full scale execution in order to ensure their appropriateness for a wider audience. This may involve the co-development of information materials to ensure they are audience appropriate.
- Indicators used to track intervention progress should include sex-disaggregated data and identify issues specific to women as well as men.

CONCLUSIONS

Communities and mining areas were selected within the six project countries based on the importance of ASM in the regions and the proximity of the project sites to international waters that may be impacted by ASM, particularly with respect to pollution from the misuse of mercury. Although the communities differ somewhat in terms of population, areal extent, cultural context, and mining history, they share a critical similarity – ASM represents an essential source of livelihood. The communities and regions targeted through the Global Mercury Project are the following:

- Kadoma-Chakari mining area of Zimbabwe
- Rwamagasa village, Tanzania
- Ingessana District in Sudan
- São Chico and Crepurizinho, Brazil
- Talawaan and Galangan, Indonesia
- Eight villages in Lao PDR

Socio-economic profiles of the GMP-target communities revealed that the population of the regions and communities assessed range widely (from 420 to 26,990 people) and the majority of mining community inhabitants are in the economically active age range (21-40 years). All GMP-target communities are of mixed ethnicity, often with multiple languages. In total, representatives from more than twenty ethnic groups reside in these communities. Education levels and literacy rates in the GMP-target communities indicate that levels are typically considerably lower than national levels. In most GMP-target communities, agriculture (crop farming and to a lesser extent livestock production) is the predominant livelihood activity, although mining can provide the most significant source of economic wealth. Mining communities surveyed generally experienced incomes above national levels, ranging from US$180 per annum to US$2400 per annum. Highest revenues are obtained in Brazil, where mining is the predominant activity in GMP-target

communities, although incomes are still considerably lower than national levels, likely due to severe regional disparities.

Local government and related services and infrastructure are commonly underdeveloped or altogether absent in ASM communities, leaving miners and their families to rely on their own resources for basic amenities. Evaluations of social infrastructure and basic amenities - including quality of housing, sanitation, health care, and education - in the GMP-target communities indicate the following:

- Houses are frequently crudely constructed using local materials, such as thatch and wood. More durable construction materials are much less frequently used (e.g. concrete floors, aluminium sheet roofing).
- Most homes and mine sites in the GMP-target communities lack basic sanitation services. Self-dug outdoor pit latrines are the most common type of toilet, causing concern for hydrologically linked water supplies.
- Water is obtained from a variety of sources, such as drilled deep wells (boreholes), shallow dug wells, springs, creeks or rivers, rainwater and occasionally flooded pits or mine shafts. Typically, water quality is perceived to be good, despite the likelihood of contamination from sewages in some cases.
- Water sources are sometimes located great distances away and water must be carried, as is the case for some residents of the Kadoma-Chakari Region in Zimbabwe, who must travel up to 5 kilometres to fetch water. Many women in Ingessana District of Sudan walk an hour or more to obtain water.
- The most serious water-quality related health risks may be in Galangan, Indonesia, where 58% of miners use abandoned mine pits for both disposal of sewage and collection of drinking water.
- Access to basic health services is typically lacking. People are hampered from obtaining treatment by the distances to clinics and costs associated with transportation or treatment. In some cases, residents must walk one half day or more to obtain medical treatment. In the best of circumstances, communities have a local pharmacy or health nurse.
- Lack of health services for childbirth is a major health issue facing women.
- Although primary schools are located within walking distance of most GMP-target communities, access to education is inadequate due to a shortage of teachers, lack of secondary schools, and distance to schools.
- In GMP-target communities, secondary education is only accessible at considerable distances from home. Costs related to secondary school attendance (transportation, accommodation and schooling fees) and the loss of labour preclude participation for most children.
- High rates of absenteeism and early dropout, as documented in most GMP-target communities, are attributed to the need for children as an informal source of labour. As children get older, the expectation to undertake mining or various types of informal labour (e.g. tending cattle, farming) increases significantly.
- Carbohydrates typically represent the bulk of the household diet. Protein sources, such as meat and fish, are less frequently consumed as they must be purchased, they are prized for their value or are scarcely available. The exceptions are communities where fish are locally available, such as Lao PDR.

- When protein is not available on site, frequency of protein consumption can be correlated with income.
- Due to the lack of protein in most diets, combined with the lack of fruits and vegetables in some communities, malnutrition is likely prevalent in some GMP-target communities.

Mining practices in GMP-target communities range from low-tech methods, as in the Sudan, to somewhat mechanized operations, as observed in some Brazilian mine sites. With respect to the misuse of mercury, the key issues include the following:

- Mercury added to ball mills or centrifugal concentrators, as observed in Talawaan and Kadoma-Chakari region, respectively, represents a significant source of mercury consumption and emissions. In Talawaan, for instance, mercury consumption is in the order of 20 to 30 tonnes per year.
- Mercury amalgamation practices are – with slight exceptions - generally quite similar between the GMP-target communities. Main differences are attributed to the price of mercury (as observed in low-mercury consuming Lao PDR where mercury cost ~US$80 per kg), the use of mercury in ball mills and centrifuge barrels (as is the practice in Talawaan and the Kadoma-Chakari region, respectively) and the application of retort-like devices.
- The fate of mercury in amalgamation tailings subjected to cyanidation is a major cause for concern. As mercury-cyanide complexes are highly soluble, they may be easily transported to aquatic systems, where mercury may subsequently be transformed into forms which can be incorporated into the food chain (e.g. methylmercury).
- The variations between methods used in the GMP-target communities may signify an opportunity for technology transfer. For example, the use of a simple bamboo condenser to recover mercury followed by lime to reactivate it was employed by some miners in Lao PDR (It should be noted that the efficacy of this technique has not been demonstrated).
- The cost of mercury substantially exceeded the international price of ~US$ 4/kg in all GMP project sites, ranging from US$18 in Rwamagasa Village, Tanzania to US$ 88 in one of the Laotian villages. Based on the practices employed in various GMP project sites, the price of mercury seems to be an important influence on the amount of mercury consumed.

One of the main environmental and human health issues in the GMP-target communities not surprisingly relates to mercury pollution. Inhalation of mercury during handling, as a result of spills and during amalgamation and amalgam decomposition (which is often undertaken by women and children) represents a major concern. Typically, this is conducted with no protection (e.g. gloves) and often takes place in the home. Of particular note, in Ingessana District, Sudan, where women are predominantly responsible for mercury amalgamation, the most common health afflictions cited by survey respondents are malaria, chest pain, dyspnoea and coughing, as well as fatigue, irritability and depression especially among women. It was observed that many of the miners suffer from eye problems (red eyes, tearing, itching etc.). It should be noted that the respiratory and neuropsychological symptoms reported are also symptoms which can be indicative of mercury toxicity.

More than 50,000 people reside in the mining areas targeted by the GMP and so may be susceptible to the environmental exposures to mercury. This may result from the mobilization of mercury from mine sites into aquatic systems, for instance from the direct discharge or erosion of tailings, and its subsequent transformation into biologically available forms (i.e. methylmercury). Once in the aquatic food chain, mercury may represent a particularly significant risk to communities reliant on fish as a primary food source. Atmospheric deposition of mercury released from burning is also a hazard for residents living in proximity to these activities.

Awareness of the environmental and human health risks associated with mercury use varied widely between and within the GMP-target communities. The level of awareness was lowest in Lao PDR, where only 2% of households surveyed indicated any awareness of the risks associated with mercury. Awareness was highest in Brazil, Tanzania and Zimbabwe. Even respondents who indicated some level of awareness could not accurately name symptoms or effects of exposure.

Ascertaining the sources of information and means of communication in GMP-target communities is critical to designing an effective intervention. In the majority of GMP-target communities, radio is a key means of obtaining information and should be considered for information dissemination campaigns. Television, word of mouth and newspapers are other important information sources. In regions with high illiteracy rates, such as the case for the Ingessana in Sudan (90% illiteracy), alternative approaches to information campaigns are needed. Demonstrations and encouraging local representatives to advocate practices are possible modes of information dissemination. Mercury dealers (who are also often gold buyers) may resist efforts to reduce mercury consumption and should therefore also be targeted by information campaigns.

In many GMP-target communities, women are predominantly engaged in gold processing including amalgamation and amalgam decomposition and so may experience equal or greater risks than their male counterparts. Furthermore, children, pregnant women and women of childbearing age should be especially conscientious of the risks from methylmercury exposure, the form predominantly found in fish. Thus, a number of gender specific recommendations for the GMP have been proposed. These include the following:

- Women should have equal access to training and information programs;
- Educational campaigns should target women in order to mitigate specific health risks, for instance related to occupational and environmental mercury exposure;
- Training seminars and disseminated information should seek to sensitize recipients – both women *and* men – as to the importance of gender equity. Key issues should include the importance of education for boys *and* girls and highlight equity in pay for work and equity in decision making;
- Training and information programs should be field tested with women as well as men prior to full scale execution to ensure their efficacy to both audiences. This may involve the co-development of information materials to ensure they are audience appropriate.

- Indicators used to track intervention progress should include sex-disaggregated data and identify issues specific to women as well as men.

It is clear that the more than 50,000 residents of the mining areas targeted by the GMP are at risk from the misuse of mercury in gold mining, in addition to the host of other social and environmental impacts associated with ASM. It is also apparent that these communities direly lack the capacity and means to address these issues. Thus, interventions and other measures to support the transformation of ASM into an activity which can impart notable benefits to impacted communities are critically needed.

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