Global Mercury Project

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

Information about the Project Site in Tanzania

Aloyce L. Tesha
Assistant Country Focal Point
GMP - Tanzania

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1. Introduction

In Tanzania artisanal and small-scale mining (ASM) activities are spread all over the country. However the Lake Victoria Goldfields (LVG) which produces more than 95% of all the gold is the most significant. Given the level of production and hence the intensity of ASM activities the area suffers the greatest impact of these activities. It is for this reason and others that the area was selected for the activities of the project. The paper provides information of the Rwamagasa Mining Centre which is within the LVG and is the selected Project Site in Tanzania. The information is a brief summary of the recently completed socio-economic survey and an overview of mining, processing, environment and health aspects of the site.

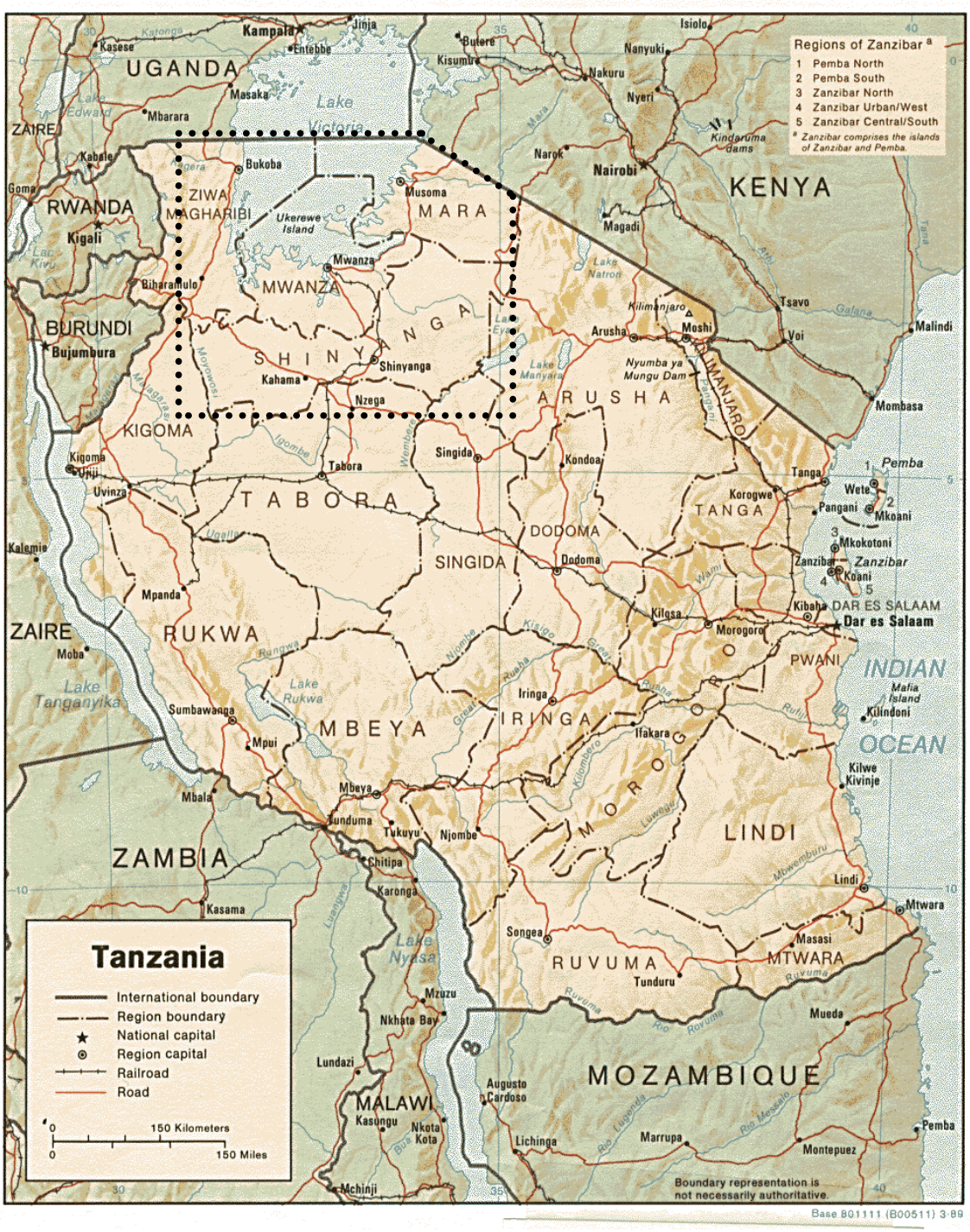

Fig. 1 - Location Map of the Lake Victoria Goldfields (Dotted box)

2. Description of the Site

Lake Victoria Goldfields (LVG) is defined as the area surrounding Lake Victoria (Figure 1 above) i.e. the administrative regions of Mwanza, Shinyanga, Tabora and Mara which are active in gold mining activities. It should be noted here that each region is headed by a Regional Commissioner and has a number of districts which are headed by a District Commissioner. Gold mineralisation in the LVG is of three types namely auriferous quartz reefs and stringers, auriferous sulphide impregnation consisting of large scale disseminated suphide replacements of banded iron formations (BIF), eluvial gold deposits in laterites and alluvial or stream sediment placer deposits.

LVG area is mainly composed of geological formations belonging to the Nyanzian System referred to as Greenstone Belts. The Greenstone Belt rocks include sequences of ultramafic, mafic to felsic volcanics, banded iron formations, felsic tuffs and volcanoclastic sediments. The volcanics with pillowed lavas and explosion breccias are key marker units identify the environment most favourable for locating massive base metal sulphide and gold deposits of the volcanogenic type. Major Greenstone Belts of the Lake Victoria Goldfields include, Geita, Rwamagasa, Kahama, Musoma - Mara, Nzega and Kilimafedha belts. It is in these belts where ASM activities are mostly concentrated.

2.1. Geita Mining District

Geita is one of the seven districts of Mwanza Region lying Southwest of Lake Victoria. The district has the largest number of mining centres than any other district around the LVG. It has four major ASM centres namely Nyarugusu, Nyakagwe, Mgusu and Rwamagasa. These have several satellite centres of their own.

Fig. 2 Location Map of Geita District showing major ASM mining centres and the drainage pattern: southwest of the map drainage goes to Lake Tanganyika while the rest goes to Lake Victoria

The Rwamagasa belt forms a flat terrain with intense alterations. Due to this thick alluvial cover, Greenstone rocks are not well exposed to the surface. Gold mineralisation occurs in quartz veins as well as secondary enrichment in rubbles at the base of laterites above the Greenstone rocks. Occurrence of gold nuggets in rubbles has been reported at Nyarugusu, Buziba, and Nyamutondo through intense widespread mining activities by ASM.

Rwamagasa village is divided into 5 *vitongoji* (sub-villages) that are: Elimu, Isenyi, CCM, Lubinga and Imalanguzo. It should be noted that when explaining the socio-economic profile of Rwamagasa it is not proper to avoid the profile of Geita District as an entry point. Rwamagasa village is located southwest of Geita town as shown in figure 2 above. In the village, there are no telecommunication services. The villagers depend upon the services available in Geita town.

2.2. Access to Rwamagasa Mining Centre

Geita town is 100 km from Mwanza by road via two ferry routes, i.e., Kamanga and Busisi. On the other hand Rwamagasa Village is 45 kilometers from Geita town on earth road. There are also two airstrips; one belongs to the Geita Gold Mining Company and the other one to the forest reserve. Dar es Salaam can be accessed from Mwanza by air which takes about 1 hour for large planes and an hour and half for small planes. There is a railway line from Dar es Salaam to Mwanza which takes 30 hours. Also Mwanza is accessible by road in different route such as Dar es Salaam - Arusha via Nairobi - Mara to Mwanza which takes about 20 hours while the central road route that is Dar es Salaam - Dodoma - Singida - Shinyanga to Mwanza takes about 24 hours. Also, one can use Dar es Salaam - Arusha via national parks i.e. Manyara, Ngorongoro, Seronera and then Mwanza. It is hard to establish the distance from Dar es Salaam to Mwanza because it depends which route one is using. However Dar es Salaam to Mwanza is approximately 1000 kilometers.

2.3. Climate

Geita District has two main rainy seasons that run from November to December and February to May with the mean annual rainfall of 1264 mm. The annual minimum and maximum temperatures for Geita range between 14°C and 30°C.

2.4. Topography

Geita district is characterized by hilly topography in the north, west and parts of the south west, with a gentle slope towards the south and southeast. There are pediments that are gently sloping towards the drainage depressions. These pediments are vulnerable to erosion, particularly where vegetation cover has been removed through cultivation, mining or overgrazing. The average attitude is 1,300 to 1,100 above sea level.

2.5. Administrative Structure

Geita town serves as the administrative center for the district. The District Council (GDC/Council) is the policy and legislative making organ as well as the overseer of all development issues in the district. The district Executive Director (DED) heads the Secretariat of the Council. The district has 43 Councilors from all the administrative wards and appointees on special seats. The three Members of Parliament (MPs) come from their respective Constituencies and at the same time serve as Councilors.

2.6. Community Socio-economic Profile

Rwamagasa Village is a typical rural area with a total population of 26,990, comprised of 13,879 males and 13,111 females, with 5,017 households having an average size of 5.4 people. On the randomly selected respondents, only 98% have lived there for more than five years. Land tenure in Rwamagasa village is granted through an allocation system managed by the village administration. Rwamagasa village as well as Geita town has a big number of people who have immigrated there in search of self employment in the artisanal mining or employment in the newly established gold mining. A few people practice licensed business, while the rest are petty traders.

2.6.1 Economic Activities

The major economic activities in Geita District are farming, livestock keeping, trading, fishing and mining. At Rwamagasa village, they produce cash crops including cotton and paddy. Other economic activities performed at the village are: artisanal mining, livestock keeping, food vendors and other petty business. Most people have an income of below Tshs 50,000 (1 US$ is equivalent to 1,035 Tanzanian Shillings (Tshs)) per month (64%), while 24% earn between 51,000 – 100,000 and only 3% get more than 200,000 per month. However, when asked about their expenditure, only 45% said that they spent more than Tshs 50,000/month and 7% said they spend more than 200,000/month. This is typical of a general pattern in the country, whereby people manage to get extra funds in one way or another, outside their regular income, in order to survive.

Gold mining, which is done in Geita district, is of two types: small-scale artisanal mining, which is conducted in 250 small scale mining sites having an average of 8.3 ha, in size, and large-scale mining, which includes sub-components of research, actual mining and master gold dealers. The majority of artisanal miners are in Nyamtondo, Rwamagasa, Mgusu, Nyarugusu and Nyakagwe wards. The residents of Rwamagasa are primarily involved in mining activities.

Among the people interviewed at Rwamagasa village, 54% are engaged in mining alone, while 14% are engaged in a combination of farming, mining and petty business, 9% practice farming alone, 7% buy gold and other minerals and 5% operate bars, hotels and guest houses. The focus group discussion reported that the major economic activities for women in that village are food vendors (mama lishe), selling vegetables in the market, saloon, tailoring and few in the mining activities. The agricultural activities are done by both women and men.

Most artisanal miners do not own claims and, every three days, 30% of the ore dug out of the ground is given to the claim holder; very few miners know the effect of mercury especially women; most of the miners were very willing to learn the new technology; and most of them are not members of mining associations.

2.6.2. Education

Geita district has 210 pre-schools, 228 primary schools and 9 secondary schools as well as adult literacy classes. The pupil drop out rate is another serious problem in the district, including Rwamagasa village. At Rwamagasa Village, there are two primary schools with 1,650 pupils, 890 boys and 760 girls. Only 18% of the respondents had higher than primary school education.

2.6.3. Health Services

The community of Rwamagasa village does not have adequate health services. They are in the process of constructing their own village dispensary. Out of 848 households at Rwamagasa, only 625 have pit latrines. The village lacks social welfare services and a police post for security.

3. Gold Production in Tanzania

Gold has been mined in Tanzania for more than 100 years. The gold production from artisanal and small-scale mining (ASM) in Tanzania is not well established but some authors indicated that the ASM might produce something around 4 tonnes of gold per annum see official gold production table 1 below[1].

Table 1. Recorded official gold production in kilograms from 1991 to 2002

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3,779.0	4,525.0	3,369.8	2,861.4	320.0	318.0	232.0	427.0	4,890.0	15,060.0	30,088.0	43,320.0

This seems very low for the large contingent of people involved in this activity. It is difficult to estimate the exact number of people directly involved in gold mining activities in Tanzania as miners migrate from one site to another going after easily exploitable gold. A population around 300,000 was estimated in 1999[2]. The gold rush for the Lake Victoria Goldfields started when the gold price increased at the beginning of the 80s.

The regions of Mwanza, Mara, Kagera and Shinyanga which surrounding Lake Victoria have a number of mining areas in its various districts. In Geita district for instance there are 7 main centres where gold miners have been operating. These areas are known locally as “mining centers”. Each of these “centers” contains a number of villages formed by the gold rushes. The number of artisanal miners in the Geita District is unknown but it is estimated to be as many as 150,000[3], in which most of them are illegal panners.

Mining on the Rwamagasa Greenstone Belt was very active in the 30’s and 50’s. The main mines in the area were Mawe Meru, El Dorado and STAMICO Buckreef Gold Mining Company. Artisanal miners have been working in the area since 1974. Outcrops are scarce in the area due to intense laterization. The gold is not of alluvial origin but it seems to be formed in place by a process of supergene enrichment. The presence of nuggets is common at the base of the laterite. Average gold grades of 25 g/t has been reported at Mweru Mine[3]. It is very common to observe in shallow pits (5 to 10 m) opened by ASM in Rwamagasa a thin (30-50cm) layer of eroded quartz fragments just underneath the lateritic cover. These fragments are also mined and this is the reason for miners being grinding the weathered ore to extract (liberate) gold.

[1] Ministry of Energy and Minerals – Statistics of mineral production in the country and in Ikingura, J.R., 1998. Mercury Pollution Due to Small-scale Gold Mining in Tanzania Goldfields. In: Small-scale Mining in African Countries: Prospects, Policy and Environmental Impacts. p. 143-158. Ed L. Landner, Dept. of Geology,k Univ. Dar es Salamm, Tanzania.

[2] van Straaten, P., 2000. Mercury Contamination Associated with Small-scale Gold Mining in Tanzania and Zimbabwe. *The Science of the Total Environment*, v. 259, p.105-113.

[3] Steffen, Robertson and Kirsten Inc., 1994. Assessemnt of Tanzania Gold and Diamond Property Rights Held by Bakertalc Inc. Vancouver, Canada, 94 p. + appendices.

The inspectors of the Ministry of Energy and Minerals (MEM), who collect 3% of the reported production as taxes (royalties), have estimated gold production in Geita region. Looking into the numbers obtained by Mr. John Nayopa (Resident Mines Officer based in Geita) and his team, the gold production from ASM fluctuates substantially. For example in 1991, when the Government was buying gold through the National Bank, the reported production was around 617 kg and dropped to something around 2 kg/annually from 1993 to 1996 when the bank stopped buying gold. When the private company Meremeta introduced a custom milling operation in 1997 and started buying gold in the region, the gold production increased from 2 kg in 1996 to 420 kg in 1998. Recently the company ended 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. As a result the Government is not collecting adequate taxes and most gold is smuggled out of the country as compared to the recorded official production Table 1 above.

The gold production in the district is calculated based on the estimate grade of the ore exploited. The inspectors establish the gold production based on the amount of ore bags being processed and whether the ore is rich or not (testing by panning). In this case the inspectors collect taxes from the miners, i.e. those extracting the ore, before they actually produce gold.

In 2002, the Geita Gold Mine, a large mine operated by Anglo Gold and Ashanti Goldfields has been producing almost 21 tonnes/annualy of gold and paying annual royalties of 3%, i.e. something around US$ 7 million for the Government. The Tanzania mining laws do not establish which percentage of these taxes returns to the municipality. As a result, the town of Geita is visibly not receiving the benefits of this massive gold production in the region.

4. Mining and Processing in Rwamagasa Mining Centre

In the Rwamagasa Mining Centre, The miners dig shafts or pits to reach the paying reef underground or the weathered lateritic material. They excavate as deep as 10 to 15 meters to reach the weathered lateritic material with layers of fragmented quartz pebbles and greenstone suite of fragmented rocks. Semi-weathered to fresh-rock ores are also mined by shafts at a depth of between 50-100 m to reach the main paying reef crossing the area and famous known as Blue Reef. Usually the miners grind a piece of ore material and test it in a pan for visible gold. The testing decides whether to continue mining or move into another pit. The gold ore rock or reef from the pits is dug out with a pick shovel after using explosives to break the hard ore rock. Hoisting the ore to the surface is by using locally fabricated wooden winches or a hoisting winch.

The ore rock at the surface is either sold to traders or (Makota as they are locally known) or transported to the milling centres which are either located in the living compounds or near Isingile river bank. Traders buy the ore on the spot based on a visual estimate and quick tests of the gold content. This sometimes is more convenient for the miners who do not need to interrupt their activities to process the material. The gold ore is moved to the milling centres using trucks, tractors, donkeys, bicycles, and humans, especially children and women. The ore is transported in polyethylene bags of 40 kg to the milling centres where different individuals are hired to crush the ore rock manually into a certain size before fed into the ball mills for final crushing into powder.

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. The cost for each individual was evaluated in 2 processing sites and it is shown in Table 2. In many cases the payment is with ore bags instead of cash.

Table 2 – Payment for Individuals to Perform the Processing Operations

Activity	**US$/kg paid to an individual**	**kg processed per day**
hand crushing	0.0125 to 0.0175	80 - 100
grinding	0.075 to 0.0875	soft: 640-720 (*) medium: 400-480 hard: 320-400
sluicing	0.0125 to 0.025	400 - 600
amalgamation	0.10(**)	10 - 20

Note: (*) grinding rates depends on ore hardness
(**) manual amalgamation: US$ per kg of concentrate processed

The ore is stacked over pieces of wood and leaves that are ignited to dry the ore. In most cases in Rwamagasa Mining Centre the ore are sun dried. The dry material is transported in 40-kg bags to the ball mills usually by women. The ball mills (∅2 x 3 ft) are powered by diesel generators and they operate with cast or forged steel balls. In one visited operation the ball charge was: 200 balls of ∅6.46cm, 800 balls of ∅4.86cm, and 200 balls of ∅3.24cm. In other site the ball charge was: 30 balls of ∅9.70cm, 570 balls of ∅4.86cm, and 600 balls of ∅3.24cm. These loads seem to occupy more than the 35-40% of the mill volume which is normally recommended for dry grinding to provide mill volume for air sweeping and dust control[4]. The mills run at speeds between 32 and 43 rpm (exceptionally 20 rpm). This seems a bit slower than the maximum allowed speed, the critical speed: $Nc = 76.63\ D^{-0.5}$ (D = mill diameter in feet) = 54 rpm. The balls mills are not sealed and there is a perforated steel plate in one side of the mill to discharge the ground product. The dust comes out in pulses and it is stacked underneath the mill. The sound is extremely loud. The operators and all people around the mill inhale an incredible amount of dust. It is not clear why the miners use dry grinding. Water scarcity does not seem to be a problem in some places. In Mgusu, for example, water is not a problem as the gold concentration step is conducted in a river that flows to Victoria Lake. It seems that wet-grinding is a result of a work division scheme. As each individual in the processing centers, including the mill owner, is paid by the amount of ore bag processed, it seems to be easier to count bags when the ore is dry.

It is clear that introduction of water in the mills will be very beneficial. In dry grinding the contact between particle and balls is lower than in wet milling. Gold can also be easily flattened and retained inside the mills when dry grinding is practiced. The dust in the milling site would be eliminated by wet grinding. As well, the energy required to grinding would be reduced since dry grinding requires at least 30% more power than wet grinding. This can be seen in the Bond Power Requirement Equation:

$Power = EF_1 \times EF_2 \times EF_3 ... W$
$W = 10\ Wi\ (P)^{-0.5} - 10\ Wi\ (F)^{-0.5}$
W = kWh/short ton
Wi = Work Index
P = Product size in micron which 80% passes

[4] Rowland Jr, C.A., 2002. Selection of Rod Mills, Ball Mills and Regrind Mills. In: Mineral Processing Plant Design, Practice, and Control. vol. 1, p. 710-754. Ed. A.L. Mular, D.N. Halbe, D.J. Barratt. SME – Society for Mining, Metallurgy, and Exploration Inc. Colorado, USA.

F = Feed size in micron which 80% passes
EF_1 = efficiency factor when dry grinding is used = 1.30

The ground ore is carried in 40-kg bags to the sluice boxes set up at the riverbanks. Gold is concentrated in 4-6m sluice boxes lined with sisal clothes. The dry ore is discharged into to 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 to fine gold particles. Tailings are left at the site or simply dumped into the river. Many miners (panners) all over Geita District have been re-processing old tailings. After processing all bags brought by the customer, the sisal clothes are washed in metallic trays and mercury is added for manual amalgamation.

In Rwamagasa, this operation is conducted by individuals who manually press mercury for at least 2 hours on a paste of concentrate (80% solids). Then, they add water to separate by panning mercury from the rest of the heavy minerals. It is visible the lack of mercury coalescence during this process. This might represent the main source of Hg loss. The final Hg-contaminated amalgamation tailing is left in a concrete tank. When the concrete tanks are full, miners dispose carelessly the Hg-contaminated tailings around the mining operations for eventual re-processing. It is common to see women re-processing amalgamation tailings.

In the Rwamagasa centre, in spite of having 8 PMLs reporting mining activities, just one concession has been constantly producing (Blue Reef Mine). The company manager mentioned Au recoveries as high as 86g/tonne of ore processed. Processing 10.5 tonnes/week, they eventually can produce 900 g of gold per week or 3.6 kg Au/month. When they reach this level of gold production they buy 3 kg of mercury per month, which derives a Hg_{lost}:$Au_{produced}$ ratio of 0.8. Official statistics (reports from Mr. Nayopa) indicate that in three different quarters (3 months) of 2002, Blue Reef produced 2.9, 2.5 and 4.3 kg of gold or about 1 kg/month. It is very difficult to obtain an accurate Hg_{lost}:$Au_{produced}$ ratio, since the gold production fluctuates considerably in function of the ore grade and/or it has not been properly reported. The price of one kg of Hg in Rwamagasa is Tzsh 20,000 (US$20), which is 5 times the international mercury price. It was not observed miners amalgamating the whole ore. Mercury apparently is used to amalgamate just gravity concentrates from sluice boxes.

4.1 Amalgam Decomposition

At Rwamagasa centre and other mining areas in Tanzania, amalgam is usually decomposed by burning 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. The heat is clearly insufficient to burn all mercury off. Miners, women and children keep watching this burning process and are evidently exposed to high levels of Hg vapor.

The use of air blowers in bonfire is an appropriate technique to increase the retorting temperature and provide highest distillation yield. This is very important in order to introduce iron-made retorts since the retorting time can be substantially reduced.

5. Environmental Impacts

Impacts of small-scale mining activities to the environment are numerous, in Rwamagasa mining centre visible impacts are the following: -

5.1. Mining Pits

In the mining centre miners dig pits to test for gold mineralisation. If the pits are not crossing the paying reef are abandon without filling them. Due to this, the area is covered by pits of various depths from 2 to 20 metres left unattended. These pits are death traps for domestic animals and even people walking in the area at night or during wet season when the pits are covered by thick grasses.

5.2. Forest Clearing

The nearby Rwamagasa forest is being cleared by the miners to obtain timber for securing the pits as well as for domestic use. Since the mining area is a flat terraine covered in most areas with the lateritic soil which is soft and not stable, the miners has to obtain timber to secure the pits. The timber is obtained from the nearby forest reserve which used to cover the entire area before the mining started in the area. As mining continue using timber the forest continue shrinking and if drastic action area not taken in five years time the entire area will have no trees left.

5.3. Sluicing and Panning along Isingile River

Panning and sluicing require a lot of water which is drawn from Isingile river. The river is a source of water for domestic use in the mining centre. Heaps of taillings can be seen along the river and various miners bringing their powdery ore for washing and amalgamation along the river. Activities are intense during dry season since the river remains with pools of water in which the miners uses for washing and amalgamation. During the wet season the river have running water and it is difficult to work along the river since the taillings will be wet and very difficult to work on without machinery and thus washing activities are minimum but intense in the living compound due to availability of water.

5.4. Heaps of Tailings in Living Compounds

The tailings are stored in living compounds in which some miners have constructed cemented ponds for washing and amalgamation. Various heaps are visible in the living compounds of the miners. These are both environmental and health hazards to the community.

5.5. Dust pollution

Dust originate from various activities of the miners including dust from the milling centre, dust from mining, transport of the powdery ore to the washing areas and dust when miners are crushing reef ore into small sizes to be fed into the ball mills.

5.6 Noise pollution

Milling centres are located within the living compounds of the mining centre. During the day when they are operational there are lots of loud noises affecting the community of the mining centre.

5.7. Mercury Pollution

Mercury is used in the amalgamation process in the mining centre in which most of it goes into the drainage pattern draining the area. During smelting mercury is released into the atmosphere and since the metal is very heavy it does not travel far from the mining centre.

During the two processes mercury enter the body of the miners by using their bare hands in the amalgamation process and by inhaling during smelting.

5.8. Health Situation

Rwamagasa is a typical small scale mining village with approx 27,000 inhabitants. Artisanal and small scale miners use mercury to extract gold from the ore. The extraction of the gold with mercury releases serious amounts of liquid mercury and toxic mercury fumes into the local environment. It is estimated that approx. 150,000 to 300,000 people work and live in similar small scale mining communities all over the country. There is no clean and safe drinking water, no waste disposal for the toxic mercury or any other waste or human discharge. Hygienic standards are extremely low and are reasons for many infectious diseases such as diarrhea, typhoid and parasitism.

Road accidents, accidents in insecure mining pits, milling centres and amalgamation ponds, malaria, tuberculosis, and sexually transmitted diseases including AIDS are the dominant causes of morbidity and mortality. No health service exists for the mining community. To improve the health status of the communities a proper health service is urgently required.

The recent health assessment indicated that mercury is a serious health hazard in the small scale gold mining area of Rwamagasa. Miners working for many years in the amalgamation or smelting process showed severe symptoms of mercury intoxication. The exposure of the whole community to mercury is reflected in raised mercury levels in the urine, and first symptoms of brain damage like ataxia, tremor and movement disorders.

The exposure to mercury for the miners and the community has to be drastically decreased. Proper mining techniques to reduce the burden of accidents and mercury exposure are essentially needed. Small scale miners need all possible support to introduce cleaner and safer gold mining and extraction technologies.

Child labor in the mining sites is common from the age of 10 on, the children work and play with their bare hands with toxic mercury. Mercury can cause severest damage to the developing brain, especially for the unborn child. Child labor with highly toxic substances must be stopped immediately.

It is necessary to prepare for mercury detoxification and to build up a system to diagnose and treat mercury related health problems in the area. The participants with intoxication need medical treatment. To implement such a system, training of health care providers is compulsory. Capacity building including establishing laboratory facilities to analyze mercury in human specimens is required. Funding of preventive campaigns and for treatment facilities is of utmost importance.

Poverty is the main reason of the disastrous health status of the small scale mining communities. Struggling for pure survival makes mining for gold a necessity to find financial resource. The daily fight for survival makes the miners put their own health and the health of their children at risk. The exposure with mercury is avoidable with simple technology like retorts. To improve the social, health and environmental situation of artisanal and small scale gold miners, an alliance of local, regional, governmental and intergovernmental bodies is needed. Cooperation between health and environmental sectors is needed on local, regional,

national and intergovernmental levels as well as an alliance with the various donor communities such as UNIDO, World Bank, WHO etc.