ENVIRONMENTAL DEGRADATION DUE TO MINING REGULATIONS AND PRACTICES IN SMALL-SCALE MINING IN TANZANIA

By

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A dissertation submitted to the University of Zambia in fulfillment of the requirements of the degree of Masters of Mineral Sciences in Mining Engineering

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DECLARATION

This is to certify that this dissertation has been written in accordance with the rules and regulations governing the award of the Degree of Master of Mineral Sciences of the University of Zambia

It is further declared that the dissertation represents my own work and has not been previously submitted for a degree, diploma or other qualification at this or another University. Where other people's work has been referred to acknowledgement has been given.

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CERTIFICATE OF APPROVAL

This dissertation of Shija Isandiko John is approved as the fulfillment of the requirements for the award of the degree of Masters of Mineral Sciences in Mining Engineering by the University of Zambia.

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ABSTRACT

Small-scale mining (SSM) activities in Tanzania are conducted using rudimentary mining tools such as shovels, hoes, picks and chisels. In most cases, mining practices do not use engineering plans and designs and usually are done haphazardly resulting in abandoned shafts, pits, trenches and other dug-outs, which result not only in land degradation but also pose great danger to both miners and other land users.

The abandoned workings, waste dumps, tailings, and debris are the major environmental degradation in SSM sub-sector in Tanzania. The other environmental degradations arise from gold processing technologies, which use mercury by both legal and illegal miners. Furthermore; deforestation, siltation, sedimentation, river blockages and deviation of sources of surface water are common environmental degradation particularly in gemstones SSM centers.

The study has also established other factors contributing to environmental degradation. These include inadequacy of institutional framework support, weak enforcement of relevant clauses in the mining legislation and limited financial investment in the sub-sector.

Furthermore, the study has established that, the legal and regulatory framework structure in relation to environmental management in the SSM sub-sector is adequate.

The solutions to combat the cause of environmental degradation by the SSM sub-sector must take into account many factors such as adequate funding from the Government and the private sector to assure application of appropriate and environmentally friendly technologies, for sustainability of SSM sub-sector. Furthermore, the Government needs to promote a better understanding of the environmental impacts of SSM activities among small-scale miners including legalization of illegal miners to conserve the environment for the benefit of the present and future generations.

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ACM	Assistance Commissioner for Mines
ACMD	Assistance Commissioner for Mineral Development
ACSM	Assistant Commissioner for Small-Scale Mining
ASM	Artisanal and Small-Scale Mining
AREMA	Arusha Miners Association
BL	Brokers License
CIM	Chief Inspector of Mines
CM	Commissioner for Minerals
DCM	Deputy Commissioner for Minerals
DIT	Dar Es Salaam Institute of Technology
DL	Dealers License
EMP	Environmental Management Programmes
EIA	Environnemental Impact Asses ment
FEMATA	Federation of Miners Association of Tanzania
GST	Geological Survey of Tanzania
GML	Gemstone Mining License
HCES	Head of Coordination and Extension Services
HEM	Head of Environment
HEX	Head of Explosives

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HCES	Head of Coordination and Extension Services
HEM	Head of Environment
HEX	Head of Explosives

HLP	Head of Legal and Policy
HLMR	Head of Licencing and Mineral Right
HPS	Head of Promotion and Statistics
HQ	Head Quarter
ILO	International Labor Organization
LVGF	Lake Victoria Gold Field
LSM	Large-Scale Mining
LSGM	Large-Scale Gold Mining
MEM	Ministry of Energy and Minerals
MCIMS	Mining Cadastre Information Management System
ML	Mining License
MRD	Mineral Resources Division
MWAREMA	Mwanza Regional Miners Association
PLR	Prospecting License with Initial Reconnaissance
PL	Prospecting License
PML	Primary Mining License
PPL	Primary Prospecting License
RTL	Resolute Tanzania Limited
RL	Retention License
RUVUREMA	Ruvuma Regional Miners Association
SSGM	Small-Scale Gold Mining
SSM	Small-Scale Mining
SML	Special Mining License
STAMICO	State Mining Cooperation
TCM	Tanzania Chamber of Mines
TGI	Tanzania Gemstone Industry
TAMIDA	Tanzania Mineral Dealers Association
TAWOMA	Tanzania Women Miners Association
TRA	Tanzania Revenue Authority
THg	Total Mercury
RMOs	Resident Mines Officers
UNIDO	United Nation of Industry Development Organization
URT	United Republic of Tanzania
WHO	World Health Organization
WDL	Williamson Diamond Mining
ZMOs	Zonal Mines Officers

CHAPTER ONE

INTRODUCTION

1.0 Introduction

The mining sector in Tanzania encompasses numerous players ranging from policymakers to individuals and companies actively participating in exploration and mining activities. Mining activities range from small-scale mining (SSM) to large-scale mining (LSM). However, this study will be limited to the SSM sub-sector only. Other mining sub-sectors will be discussed where necessary for comparison.

In the Tanzanian context the term "small-scale mining" is defined as the mining operation conducted by Tanzanian mineral right owner holding a Primary Mining License (PML), issued under division D of the Mining Act of 1998 and amended in 2004 (URT, 1998 & 1999), [see also Appendix K].

SSM activities are carried-out in many parts of the country targeting many different types of mineral commodities particularly gold and gemstones. The mineral discoveries by artisanal miners in the late 80s and early 90s have significantly increased the level of SSM activities throughout the country. Most operations are carried-out in the remote areas where law enforcers are rarely available. Some of the SSM operations are in the most sensitive ecological areas e.g. the Lake Victoria Gold field (LVGF).

Mineral Resources Division (MRD) governing the mining sector is widely distributed throughout the country under the Zonal Mines Offices (ZMOs) and Resident Mines Offices (RMOs). Most of these offices lack appropriate and adequately trained human resources (mining engineers, metallurgists, geologists, gemologists and environmentalists) for effective administration, monitoring, supervision and enforcement of relevant mining and environmental legislations.

This has resulted in SSM activities being conducted without proper technical guidance and training on safety, health and environment. Furthermore, poor application and inaccessibility to mining and processing technology have been detrimental to the sub-sector. Consequently, SSM has been associated with numerous environmental degradations, which are a drawback to the growth, development and sustainability of the sub-sector.

1.1 Statement of the Problem

The mining sector, like other sectors of the economy in Tanzania has witnessed an unprecedented growth both in terms of output and scale of operations. For instance, there were 2,609 primary mining licenses (PML) issued in 2000 and this number, by 2006, had almost trebled to 6,537 licenses representing an increase of 151% (MEM, 2006). Similarly, the export of various mineral commodities also has shown a steady growth over the years. For instance, the foreign exchange earnings from export of gemstones produced by SSM was US$7 million in 1995 and this had risen to US$27 million in year 2005 representing an impressive increase of 286% in a period of only ten years. Furthermore, the number of people participating in SSM activities has also tremendously increased over the years. For instance, there were 550,000 small-scale miners in 1995, which by 2005 had doubled to 1.2 million miners representing an increase of 118% in a period of just 10 years (MEM, 2006).

However, the rapid growth of the SSM sub-sector has also resulted in environmental degradation due to a number of factors such as:

- Deforestation;
- Improper mining techniques resulting in poor mining practices;
- Abandoned shafts, trenches, dugout holes and pits rendering arable land useless for other economic activities;
- Siltation and deviations of sources of surface water resulting in

sedimentation;

- Deposition of chemicals in water bodies and areas surrounding mines; and
- Air pollution, noise and vibrations from drilling and blasting and crushing.

Furthermore, environmental degradation has also resulted in disturbance of ecosystems, relocation of inhabitants from their indigenous areas of habitation, destruction of flora and fauna and other creatures' settlements (Msemo, 1995).

This research work seeks to establish the extent of environmental degradation in SSM centers. The research work also seeks to assess the adequacy of the existing environmental legislation and the institutional framework support as regards to environmental degradations caused by the SSM sub-sector.

1.2 Objectives of the Study

The major objectives of this research are to:

1) Assess the social-economic significance of SSM to the nation economy;
2) Establish the forms and extent of environmental degradation caused by small-scale miners;
3) Assess the impact of existing legislations and institutional framework support on environmental degradation; and
4) Propose appropriate intervention measures to mitigate the environmental degradation propagated by SSM activities

1.3 Research Hypothesis

SSM activities, if not properly regulated, can lead to irreversible environmental degradation. Currently, the pieces of mining legislation and the institutional framework seem inadequate to effectively protect the environment. Proper

regulatory mechanisms will lead to environmental sustainability of SSM.

1.4 Significance of the Study

The economy of Tanzania is growing and needs commodities such as minerals to support its growth. However, the extraction of minerals should not be at the expense of the environment but should be done in a way that is sustainable for the present and future generations to meet their own needs. Therefore the significance of this study is high as it will, among other things:

- Establish the various forms of environmental impacts caused by SSM activities in Tanzania;
- Identify any deficiencies in the existing legislation and institutional framework support with regard to environmental protection;
- Demonstrate the importance of applying appropriate mining and processing technologies in averting environmental degradation; and
- Demonstrate the importance of sustainability of the SSM sub-sector.

1.5 Scope of the Research

Although the mining sector is composed of various classes ranging from small-scale to large-scale, the study will be limited to SSM sub-sector only. Other mining sub-sectors will be discussed where necessary for comparison.

The scope of this research work is based on the following:

- Assessing the significance of the SSM sub-sector to the national economy;
- Reviewing the mining and processing technologies employed by SSM to ascertain how they contribute to environmental degradation;
- Reviewing the environmental degradations caused by SSM sub-sector with the aim of assessing its impact at national as well as at the local level (i.e.

mining centers) and proposes appropriate measures to be undertaken. This will form the major focus of the study; and

- Assessing the impact of mining legislation and institutional framework support with respect to environmental degradation caused by SSM.

1.6 Research Methodology

A number of activities were undertaken as part of the methodology to achieve the objectives as discussed in the subsequent sections. Methods employed in the study include:

- Literature review of relevant research works and other publications undertaken in Tanzania and other countries;
- Study of the technologies employed both in gemstone and gold SSM centers to ascertain how they have contributed to environmental degradation;
- Field visit to 32 gold and 14 gemstone SSM concessions and interviewing the owners of the mines using questionnaires (Appendix J) to collect information regarding the environmental degradations resulting from mining and processing technologies by small-scale miners;
- Administering a questionnaire to Government officials at the Ministry's Head Quarters, Mineral Resource Division (MRD) in DSM and ZMOs on how SSM sub-sector is being administered in the country (Appendix I). In the assessment of the social-economic significance of SSM sub-sector, zones visited include Lake Victoria (LVZ) and the Southern Zone (SZ)

Due to limited time, data collection was augmented by direct interviews with small-scale miners. This ensured the correctness and effectiveness of the questionnaires and to clarification of a few things, which might have not been clearly understood by small-scale miners.

CHAPTER TWO

LITERATURE REVIEW

2.0 Environmental Impacts Caused by SSM

Environmental degradation can arise from LSM, MSM and SSM operations. Only environmental impacts from SSM activities will be discussed in this work.

2.1 Deforestation

Deforestation in Tanzania is very common in SSM centers where substantial amounts of trees are cut annually to clear sites for opening up new shafts and pits. Forests are also cleared for the purpose of construction of dwelling houses and timber acquisition for support and other domestic uses. With few exceptions (i.e. of areas within the Government forest reserves) all other mine sites are surrounded by extensive tracts of deforested land.

In most cases artisanal miners invade forests, causing severe environmental destruction by felling valuable old indigenous trees in order mine gold and other valuable minerals such as gemstones. For instance, the Eastern Arc Mountain Forests, stretching from Kenya's Taita Hills to Udzungwa Mountains in URT, have been severely depleted of vegetation by artisanal miners. These forests are globally recognized as biodiversity hotspots because of their rich, unique, and diverse plant and bird species. They serve as a critical global gene-bank and are internationally recognized as a priority for conservation (Afrol News, 2006).

2.2 Land Degradation

2.2.1 Dug-outs (Pits, Shafts and Trenches)

SSM centres in Tanzania are characterized by abandoned pits, shafts, trenches and other dug-outs, which are neither fenced nor backfilled after mine closure.

These dug-outs pose great danger to animals and other land users including the miners themselves. Furthermore, the dug-outs render the arable land useless for other economic activities such as farming and livestock rearing.

2.2.2 Waste and Tailings Disposal

Waste and tailings generated by SSM and processing activities contributes significantly to land degradation. Most small-scale miners do not demarcate their mining concessions to accommodate wastes and tailings disposal. Wastes, such as rubbles, debris and tailings are dumped indiscriminately in the mining concessions resulting in the arable land becoming useless for other economic activities (Landner, 1995).

2.3 Siltation, Sedimentation and Deviation of Surface Water

When panning is carried out along rivers and streams, tailings are dumped in a way that the river and streams courses are changed because of the huge piles of rubbles, debris and tailings (Landner, 1995). For instance, south of Sakale in Rugurefu village, local communities have diverted the river from its original course to a man-made canal to give a way for gold mining. This area is a catchment area for streams and rivers like Sigi, which supplies water to Muheza District and Tanga Municipality (Afrol News, 2006).

Most streams and rivers in gemstone and alluvial gold mining fields are affected in two ways, when minerals are mined from the sediments in the riverbeds and banks and when rivers are used for washing of gold and gemstones. In both incidences, rivers are subjected to siltation, sedimentation and sometimes to deviation or ponding to let mining progress. In Lake Victoria for instance, it is a common phenomenon to find muddy water in some small-bays of the lake due to gold panning and washing (Kaaya and Kinabo , 1995).

2.4 Mercury Use in Gold Recovery

2.4.1 Mercury Contamination in Gold Amalgamation

In gold mining, crushing and grinding are done by hand and the pounded ore is treated with metallic mercury, whereby the very fine-grained gold amalgamates with mercury. Some organized miners use improvised grinding system (ball mills) to ground the ore to powder form. Amalgamation is done at the processing site, along riverbanks or in unprotected ponds in residential areas. Liquid mercury is released into the environment during gold amalgamation (Ikingula, 1998). The remaining mercury in the tailings enters the drainage system where it is incorporated in the food chain. From the 1980s, artisanal mining of gold was popular and there was an intense gold rush, which involved a larger number of local people using mercury in gold recovery (Ikingula and Mutakyahwa, 1995)

2.4.2 Amalgam Decomposition

Amalgam is decomposed by burning in bonfires. The miners put the amalgam in a shoe polish tin and then into a bonfire covered with charcoal. The heat is clearly insufficient to burn all the mercury off while miners, mostly women and children, watch and are evidently exposed to high levels of mercury (Hg) vapor (Ikingula and Mutakyahwa, 1995). Mercury is introduced into the environment

through burning of the amalgam in open air. The recovery of Hg and Au from the amalgam using retorts is practiced by few advanced miners.

2.4.3 Mercury Pollution and Effects

Notwithstanding its being economically important, however, small-scale gold mining (SSGM) has been the subject of strong opposition in recent years due to its negative environmental and social impacts. Foremost is the mercury pollution brought about by the practice of amalgamation in gold recovery. Amalgamation results in the careless release of mercury into rivers and waterways, along with other mine tailings. This impairs human health by polluting the water supply and contaminating fish and other marine organisms which are sources of food (Reuther and Malm, 1995). The potential effects of this exposure on people are neurological but other problems such as complications in the reproductive and other body organs may likewise occur (Danilo, 2000)

When amalgam is blowtorched by miners and gold shop workers, vaporized Hg is released into the air and inhaled by them and people close-by. The potential long-term effect on the health is the impairment of the metabolism of the nervous system that can cause neurobehavioral disturbances (Ikingula and Mutakyahwa, 1995)

About 55-60% of the mercury is directly released into the environment whilst burning the amalgam in open air and re-burning in dealers' shops widely disperses mercury and transports to remote areas (Lacerda, 1997).

Mercury amalgamation and retorting in open air does not only affect miners, but also affects the riparian communities who live and depend on other economic activities such as fishing and agriculture (Ikingula and Mutakyahwa, 1995)

The estimated global atmospheric mercury emission caused by man is up to 3,500 tonnes per annum (Ikingula and Mutakyahwa, 1995). In last decade's studies, mercury has been found in water, sediments, soils and tailings from several mining centers in the LVGF (Ikingula and Mutakyahwa, 1995). The result indicates the presence of mercury concentrations several times higher than background levels in different environmental media. Mercury concentration is in the range of 0.01-6.8μg/l (mean 0.68μg/l) in rivers water, 0.02- 140μg/g (mean 4.9μg/g) in river sediments and 0.05- 28μg/g (mean 3.4μg/g) in soil from mining areas in the LVGF (Ikingula and Mutakyahwa, 1995). The concentration are obviously higher in comparison with the reported mercury levels of <0.01μg/l in the world non contaminated river water and <0.3μg/g in river sediments (Ikingula and Mutakyahwa, 1995)

The ratio 1.4:1 of Hg: Au calculated for the amalgam produced by artisanal miners in the LVGF suggests that for every tonne of gold produced about 1.4 tonnes of mercury is released into the environment (Ikingula and Mutakyahwa, 1995). According to the official statistics, about 4 tonnes of gold are produced by small scale miners annually. This means that 5.6 tonnes/year of mercury are released into the atmosphere from SSGM activities alone in Tanzania.

2.5 Dust Exposure

SSM is labor-intensive, with low levels of mechanization. Working conditions are generally far removed from international labor standards. Dust emissions in SSM occur during drilling of blasting holes, blasting operations, ore and waste management, crushing and grinding (Kahatano and Mnali, 1995). Small-scale miners lack respiratory protective gears and are at high risk of contracting respiratory diseases such as chronic silicosis and TB (Magne, 2002).

2.6 Mining Practices in SSM

SSM activities in Tanzania are conducted using rudimentary mining tools such as shovels, hoes, picks and chisels. In most cases, mining practices do not involve the use of engineering plans and designs and usually mining is done haphazardly resulting in numerous abandoned shafts, pits, trenches and other dug-outs, which become death traps for the miners and other land users.

Furthermore, waste and debris are dumped carelessly in the mining concession as seen in SSM centers in the Lake Victoria God Field. The abandoned workings, piles of wastes, debris are some of the major sources of environmental degradation in SSM sub-sector (Marcello, 2004) resulting into arable land becoming useless for other economical activities such as agriculture and livestock raring.

2.7 Processing Technologies in SSM

The processing technology employed in gold recovery involves several phases:

- Crushing of ore to the size compatible to the grinding system available;
- Grinding, using a wooden motor with an axle as a pestle. Advanced miners use improvised ball mills;
- Pre-concentration of fine-gold particles using sluice boxes;
- Amalgamation phase where mercury is added in gold concentrates to obtain a mercury-gold amalgam (Ikingula and Mutakyahwa, 1995); and
- Burning of amalgam using retort. Illegal miners burn the amalgam in open air releasing mercury vapour into the ecosystem (Straaten, 2000).

Mercury is a major environmental and health problem in gold amalgamation. Therefore, safety measures should be put in place when burning amalgam.

However, processing phases in gemstone mining do not involve the use of chemicals and a few phases are observed:

- Sieving of the mined gemstone material;
- Washing of the mined gemstones involving sifting and usually it is done within river or stream systems, gemstones and other heavier gravel materials are left behind; and
- Sorting phase to separate gemstones from the rest of the gravels.

Rubble, debris and tailings are eventually dumped in the river system and within the mining concession and are the source of the environmental degradation in gemstone small-scale mineral processing phases.

2.8 Legal and Institutional Framework Support

Before 1998, the Mining Act of 1979 controlled the mining activities in Tanzania. This Act had not demarcated the environmental requirements for the two sub-sectors LSM and SSM. This resulted in most activities at small-scale level being operated haphazardly without a clear understanding who is a small-scale miner, artisanal and illegal miners.

The introduction of the investment policies in the early 1990s resulted in a new Mining Act of 1998 and the Regulation of 1999. The new Mining Regulations of 1999 has clearly set out environmental requirements for SSM by specifying how mining and processing should be employed by the miners to avoid unnecessary environmental degradation. However, there is still a large group of miners who conduct mining and processing without abiding by the regulations resulting in a number of environmental degradations.

The institutional framework structure of the Mineral Resources Department has been limping all along because of lack of enough trained human resources to

manage the supervisory role, technical and institution of relevant legal mining legislations. Furthermore, the mine offices were only located in few regions targeting few mineral discoveries by artisanal miners. The licencing system was tedious and bureaucratic and one had to travel to DSM or Dodoma to look for a primary prospect license for minerals in consideration. This system encouraged illegal mining activities and resulted in environmental degradation and loss of government revenue.

Despite having numerous mine offices throughout the country, the institutional framework support is hampered by the lack of trained and experienced human resources at the ZMOs to manage the mining sector particularly SSM. This has resulted in the sub-sector being administered without proper technical guidance resulting in numerous environmental degradations.

2.9 Structure of the Mining Sector

The structural composition of the sector encompasses policy makers, regulators, facilitators and mining companies. However, mining operations range from SSM to LSM. In subsequent sections, the various players in the mining sector are discussed.

2.9.1 Government Institutions

There are a number of Government institutions, which play a major key role in the administration, monitoring and development of the mining sector. The major ones include:

- Ministry of Energy and Minerals (MEM)
- Ministry of Environment (ME)
- Ministry of Local Government (Regional and Local Authorities (RLA))
- National Environmental Management Council (NEMC)

2.9.1.1 Ministry of Energy and Minerals (MEM)

It is the mother ministry of the mining industry in the country. It is composed of two major departments, the energy and minerals departments. The minerals department is responsible, among other things for, overseeing administering and management of the mining industry in the country as the overall regulator of the mining industry.

2.9.1.2 Ministry of Environment (ME)

It coordinates, formulates and administers the environmental policy and all environment related legislations across Government departments, NGO's, and other organizations in the country.

2.9.1.3 Ministry of Local Government: Regional and Local Authorities

Most of the mineral prospects and mines are found either within the region or local authorities. The major role of RLA is to ensure harmonized relationships among all mining related players and the community. Furthermore, the RLA creates a conducive environment in the mining industry so that actors can work in a more collaborative and cooperative way with the rest of the society. This includes intervention of unforeseen conflicts between LSM and SSM or mining related players and other land user such as farmers, livestock keepers to mention a few.

2.9.1.4 National Environmental Management Council (NEMC)

NEMC was established by Act no 19 of 1983 to perform an advisory role to the Government on all matters related to environmental management. The major functions of NEMC include:

- Advise the Government on all technical matters for effective environmental management;
- Coordinate all technical activities of all bodies concerned with environmental matters in the Government and other stakeholders;
- Enforce environmental regulations (norms, standards, guidelines); and
- Promote and assist with environmental information, communications and capacity building.

2.9.2 SSM Sub-sector and Major SSM Centers

SSM operations are carried out in many parts of the country targeting many different types of mineral commodities particularly gold and gemstones. Figure 2.1 shows mining districts and the minerals exploited by small-scale miners, the highlighted ones being the ones covered during this research.

These minerals include, gold, gemstones (sapphires, tanzanite, varieties of garnets, amethyst, alexandrite, zircon and tourmaline), industrial base minerals (phosphate, kaolin, dolomite, limestone rock, graphite, salt and gypsum), building minerals (sand, gravel, aggregate, and clay) and diamonds

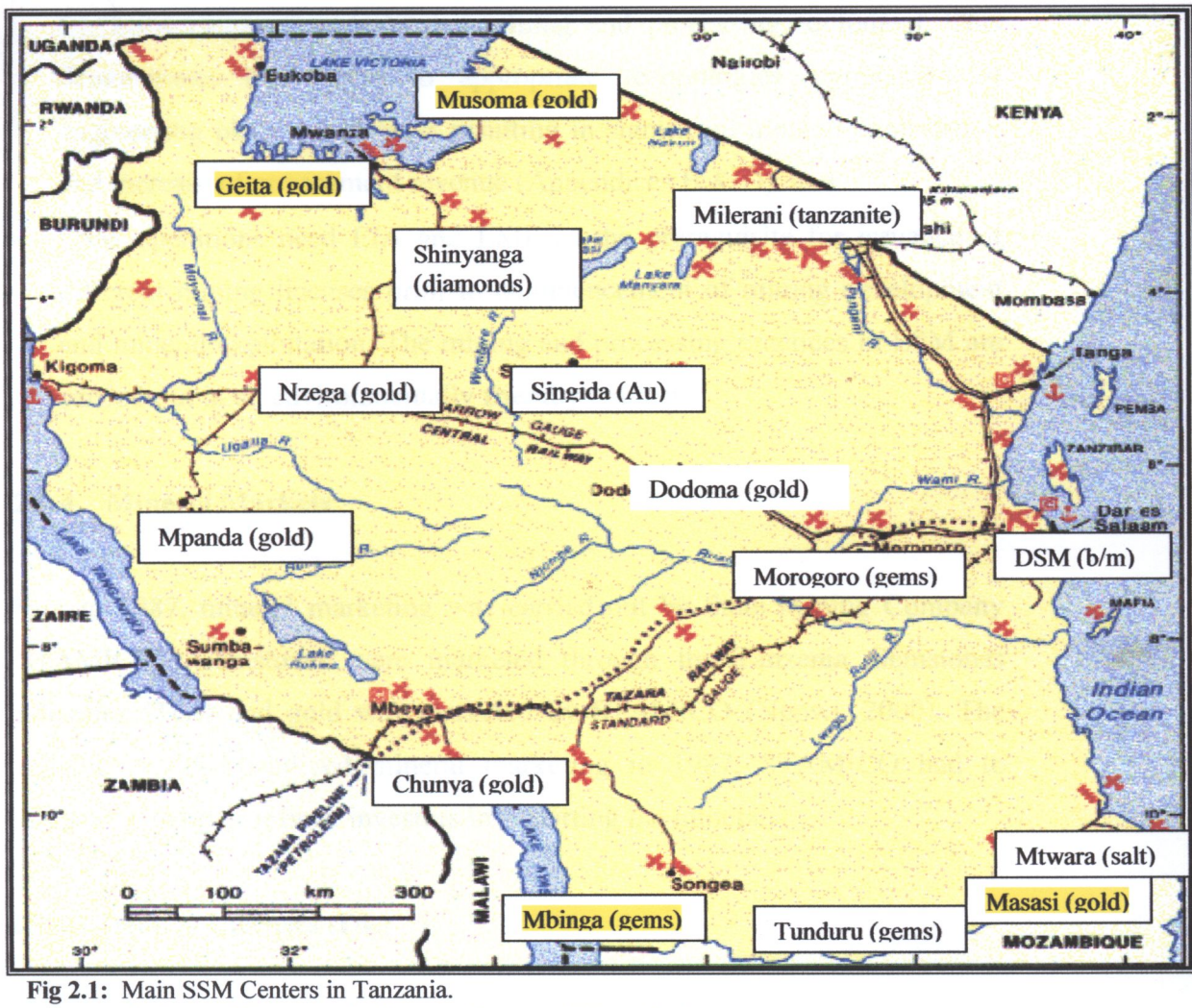


Fig 2.1: Main SSM Centers in Tanzania.
Source: Ministry of Energy and Minerals, February 2007, DSM

2.9.3 Medium-Scale Mining and Large-Scale Mining

The introduction of investment policies and fiscal mining incentives in the early 1990s led to a great impact on LSM, which has shown a significant growth in terms of size and operations (Appendix C). The features of LSM include:

- The increase of exploration licenses of different type of the minerals (Prospecting Licenses, Reconnaissance Licenses and Retention Licenses) (Appendices A & F).
- The size of the mining licenses range from $1km^2$ to $10km^2$ for GML and ML and SML respectively and most prospects are in the LVGF (Appendix

E). LSM employs sophisticated mining and processing equipment. This demonstrates the access to appropriate technologies, application of engineering plans and designs resulting in significant mineral exploitation and increase of government revenue (Appendices B & D); and

- LSM operations need EIA and EMP as the prerequisite for issuance of different mining licenses prior to commencement of mining development and mineral exploitation. The mining and processing practices in LSM are carried-out in an environmentally friendly manner.

2.9.4 Mineral Markets

Prior to 1987, mineral marketing was carried out by State Mining Company (STAMICO). Gemstones were marketed through the Tanzania Gemstones Industries (TGI) and gold was marketed by STAMICO (Ngowi, 2000). The introduction of liberalized mineral marketing in 1987, STAMICO had to compete with other private investors in exporting the minerals.

2.9.4.1 Dealers Licenses (DL)

The dealer's license is issued under section 74 of the Mining Act of 1998 and amended in 2004 and is valid for a period of twelve months renewable. The licence authorizes the dealer to buy minerals from brokers' license holders or from fellow dealers' license holders. The dealers' license holder is allowed to export minerals after declaring the same to Tanzania Revenue Authority (TRA) prior to issuance of export permit by the Mineral Resources Department (MRD).

2.9.4.2 Brokers License (BL)

The brokers' license is issued under section 81 of the Mining Act of 1998 amended in 2004 by the ZMO and RMO who is an in charge of the respective

zone/resident within the jurisdiction the license will have to operate. BL is only meant for Tanzanians as stated in the Mining Act of 1998.

2.9.4.3 SSM and LSM

All SSM/LSM are authorized to deal in mineral marketing and export of the same after fulfilling exporting procedures. All exports are declared to TRA prior to issuance of the export permit by MRD.

However, there are also illegal dealers who operate on the black market financing illegal miners and are a source of environmental degradation and loss of Government revenue.

2.9.5 The Non-Governmental Organizations (NGOs)

There are numerous NGOs and companies which also play a role in the development of the mining industry in the country.

2.9.5.1 Tanzania Chamber of Mines (TCM)

It was formed in 1990 and represents interests of large-scale mining companies.

2.9.5.2 Tanzania Mineral Dealers Association (TAMIDA)

It was created in 1989 in an effort to streamline mineral marketing activities.

2.9.5.3 Tanzania Women Miners Associations (TAWOMA)

It was formed in 1996 with an intention of promoting women participation in mining related activities particularly SSM activities. Currently the association is not very active because of lack of operational funds.

2.9.5.4 Regional Miners Associations (REMAS)

They were formed in the late 1980s with an intension of coordinating SSM activities within the respective regions and to work in cooperation with the ZMOs in providing extension services to small-scale miners.

Very few REMAS are still actively working in their areas. They include MWAREMA, AREMA and RUVUREMA of Mwanza, Arusha and Ruvuma Regions respectively to mention a few

2.9.5.5 Federation of Miners Association of Tanzania (FEMATA)

Formed in early 1990 and is meant to safe guard the interests of REMAS at the national level.

CHAPTER THREE

SIGNIFICANCE OF THE SSM SUB-SECTOR IN THE ECONOMY

3.1 Employment Creation

In the United Republic of Tanzania (URT), the mining sector has increased spectacularly during the last three decades. It is difficult to know the exact number of miners involved in artisanal and SSM in Tanzania due to their migratory nature that depends on sporadic mineral discoveries.

Figure 3.1 shows a steady increase in the number of people fully participating in SSM sub-sector from 550,000 miners in 1994 to1.2 million miners in 2005. This represents an increase of 118% in a period of just 10 years.

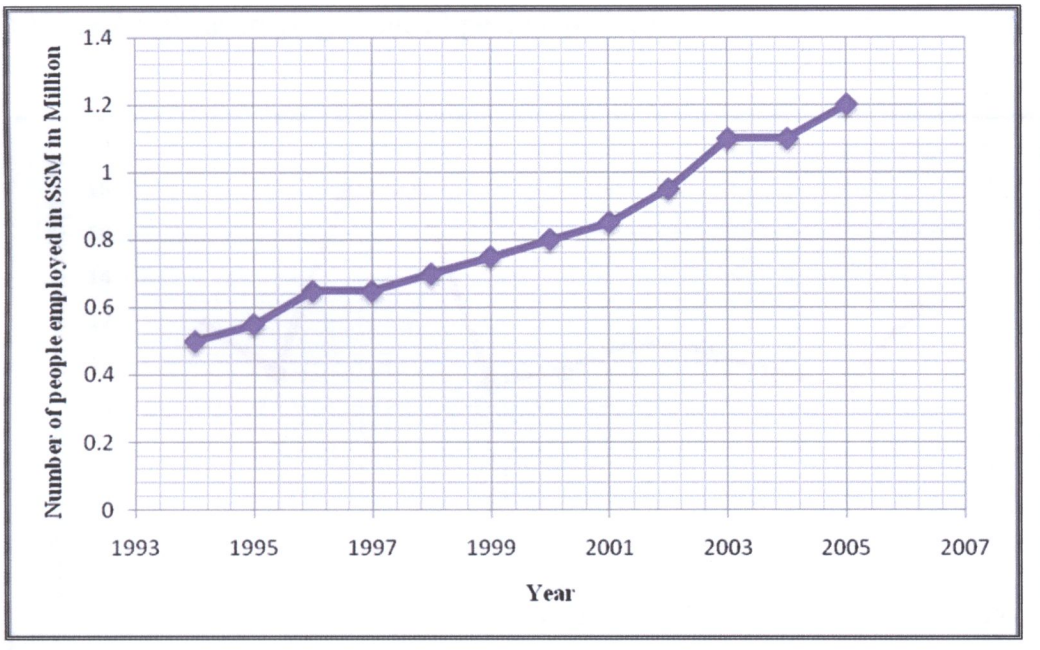


Fig. 3.1: Employment in SSM 1994-2005
Source: Ministry of Energy and Minerals, DSM HQ, February 2007

Figures ranging from 500,000 to more than 1.0 million have been given on political platforms. However, sources on which these figures are based are limited (Mutagwaba et al, 2004).

The SSM sub-sector provides employment to most people living in rural areas where there are no opportunities in formal employment. This can be demonstrated by a steady increase of number of people who depend on SSM activities (Figure 3.1). The income obtained from informal employment plays an important role in improving the living standards and facilitates in developing rural communities' benefits such as school, hospitals, roads infrastructure, clean water, electricity to mention a few.

3.2 Income Generation

Figure 3.2 shows a significant growth in income generated by SSM between 1995 and 1997 averaging about 12 percent per year.

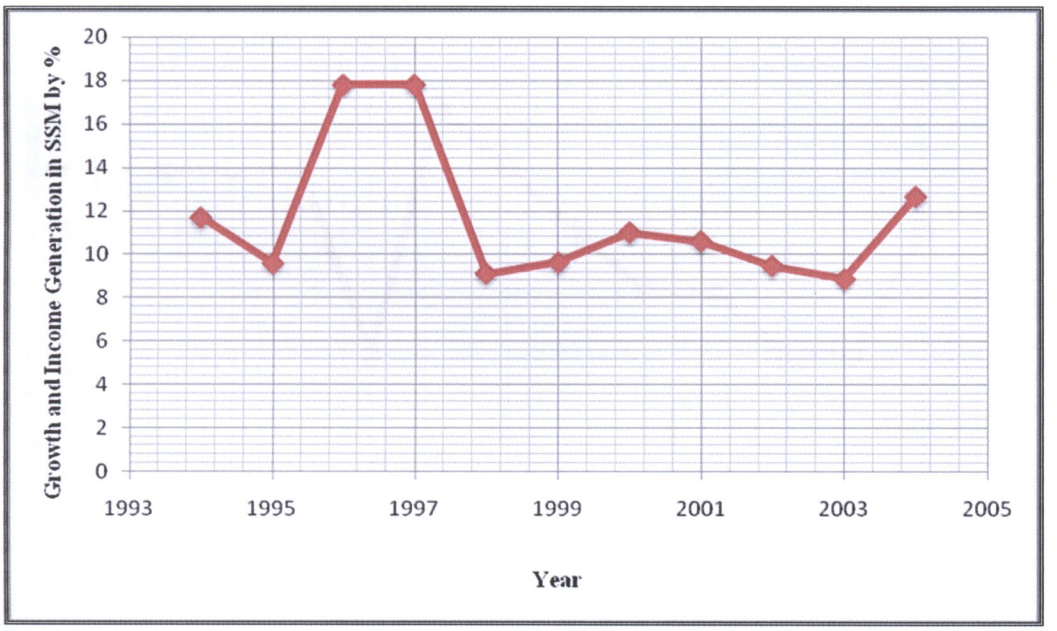


Fig 3.2: Growth and Income Generation in SSM 1994-2005
Source: Ministry of Energy and Minerals, HQ, DSM February 2007

During that period, the Ministry of Energy and Minerals was running a project sponsored by the World Bank, which was meant to develop the SSM sub-sector and encourage the formation of Regional Miners Association (REMAS). The coming of REMAS at the regional level resulted in the formation of FEMATA, which unite small scale miners at the national level. During that period, many people were attracted by SSM activities and hence the impressive growth.

Similarly, there has been also a steady growth of about 12% of the income generated from the SSM sub-sector between 1998 and 2004.

3.3 Foreign Exchange Earnings

The contribution of SSM sub-sector to foreign exchange earnings was steady (Figure 3.3) between 1994 and 1996. During that period, all minerals produced by small-scale miners were bought by the Central Bank of Tanzania (BOT) and that provided a reliable market for the miners.

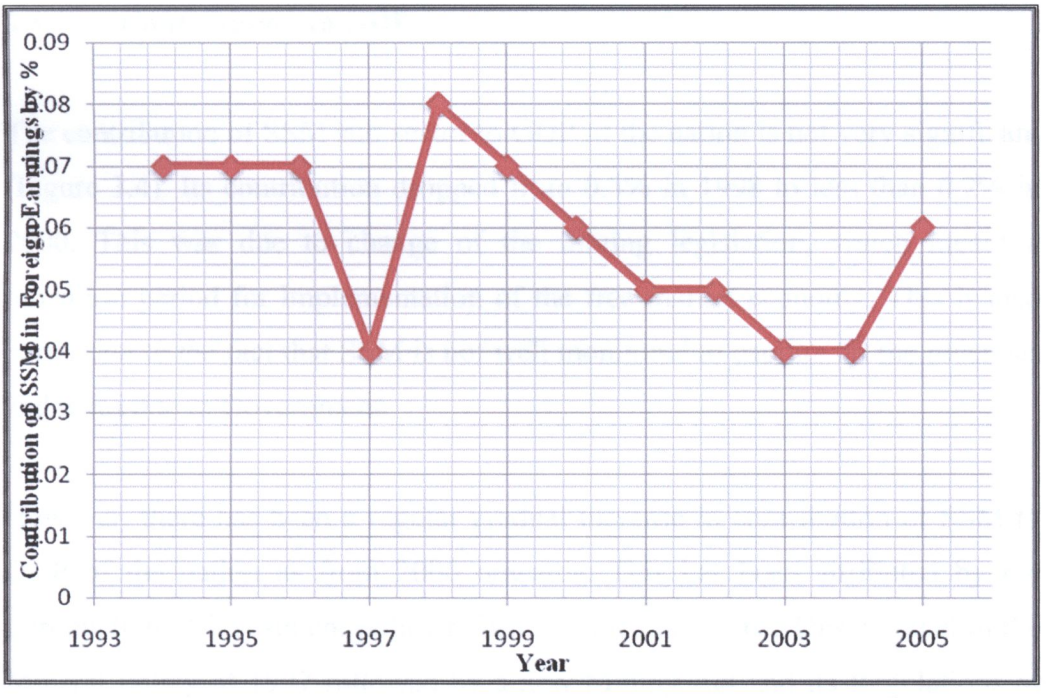


Fig 3.3: Contribution of SSM in Foreign Exchange Earnings 1994-2005
Source: Ministry of Energy and Mineral, DSM HQ, 2007

However, the Government pulled out from active participation in production not only in mineral sector but also in all other sectors of the economy due to changes in investment policies in the early 1990s. The role of active participation in production in all sectors of the economy was left to the private sector alone.

The coming of the private sector required stabilization before the mining sector could adjust to free market reforms and hence the decline in mineral exports between 1996 and 1997 (Figure 3.3).

The decline in trend observed between 1998 and 2001 was due to changes in the Mineral Policy in 1997, which resulted in a new Mining Act of 1998 and its Regulations of 1999. These two instruments encouraged active private sector participation in production. The incoming of the private sector needed time to stabilize before it could fully take charge of the sectoral activities and hence the decline.

3.4 Contribution to GDP

The contribution of SSM sub-sector to GDP of the nation is not very significant (Figure 3.4). Its contribution dropped from 0.3% in 1998 to less than 0.2% in 2000. This was due to change of the mining legislation, which meant a transition period for implementation of the free market economy. This is also partly due to the fact that SSM is not well monitored to capture all the revenues and taxes due to Government.

However, there has been a regular gradual increase in contribution of SSM to GDP of the nation as from 2000 onwards. This has been attributed by the introduction of investment policy reforms in the late 1990s. This resulted in the Mineral Policy of 1997 followed by a new Mining Act and its Regulations of 1998 and 1999 respectively, which encouraged the growth of SSM sub-sector.

The coming of the private sector in active participation in production needed time to fully take charge of the sectoral activities and hence the meager contribution of the sub-sector to GDP.

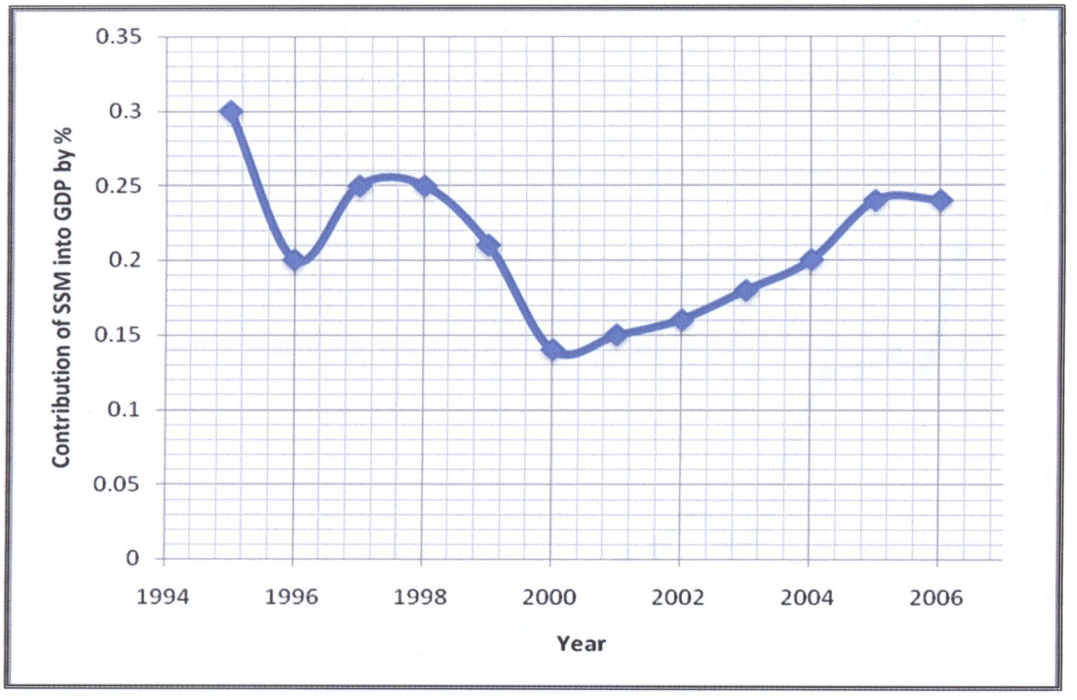


Fig 3.4: Contribution of SSM to the GDP 1994-2005
Source: Ministry of Energy and Minerals DSM HQ, February 2007

3.5 Mineral Production and Exports

3.5.1 Gemstone Production and Exports 1980 - 2005

Gemstone mining showed a significant growth from early 1990s due to a number of gemstone deposit discoveries in the country (Figure 3.5).

For instance the discovery of sapphire in Mbinga District in Ruvuma Region in 1993 and the discovery of a variety of gemstones in Tunduru, Mahenge, Liwale, Ruangwa districts in the southern zone from 1995. This discovery attracted a number of gemstone miners and dealers from all over the world. However the statistics, which are being provided, are not accurate enough

because of poor marketing arrangements, which were dominated by black market.

The steady growth in production and exports of gemstones after year 2000 was due to the increase of tanzanite production by SSM in the Manyara region. Tanzanite, a bluish precious colored stone is only found and mined in URT.

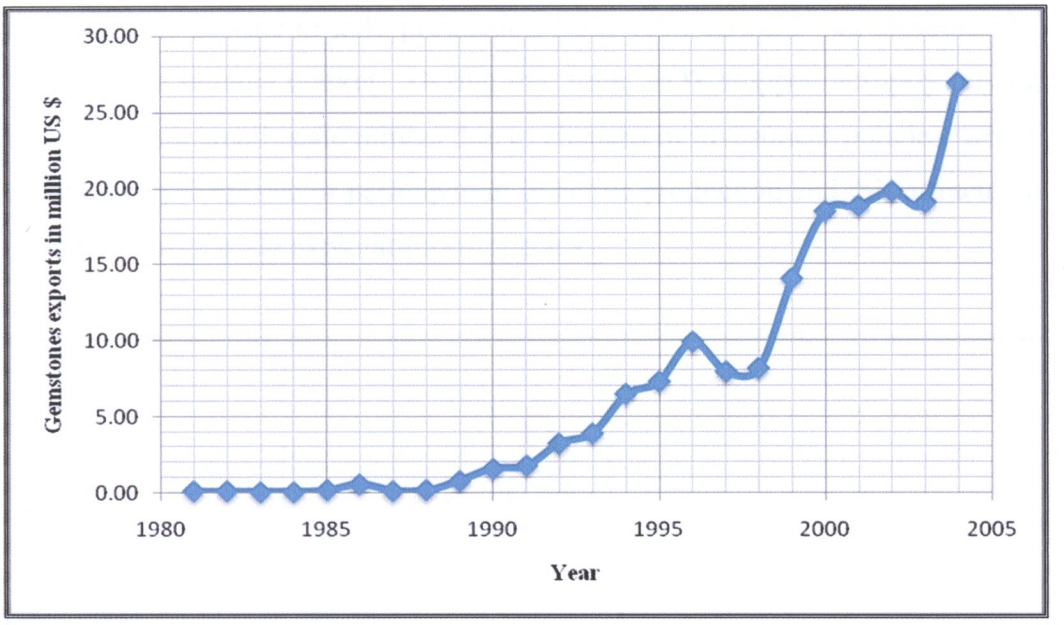


Fig 3.5: Gemstone Production and Exports by SSM 1981-2005
Source: Ministry of Energy and Minerals, DSM HQ, February 2007

3.5.2 Gold Production and Exports 1981-2005

SSM in URT is dominated by gold mining operations mostly based within LVGF in the Lake Victoria Zone. There was notable increase in gold production and exports from SSM between 1990 and 1994 (Figure 3.6). This was due to the following reasons:

- There were a number of newly easily exploitable gold discoveries throughout the country, mainly within LVGF in the Lake Victoria Zone, Lupa Gold Field on the central and western zone, Mpanda Gold Field and

Mbinga Gold Field in the Southern part of the country, which attracted a number of people in the sub-sector; and

- During that period, miners were assured of a reliable market, all gold from SSM was bought by the BOT. The BOT had opened operational branches all over the country offering competitive prices that weakened the strength of the black market.

However, the decline in gold production from 1994 onward was attributed by the lack of a reliable market. During that time, BOT stopped abruptly buying the same from small-scale miners due to changes in investment policies, which encouraged private sector participation in active production and this attracted a number of large scale exploration companies.

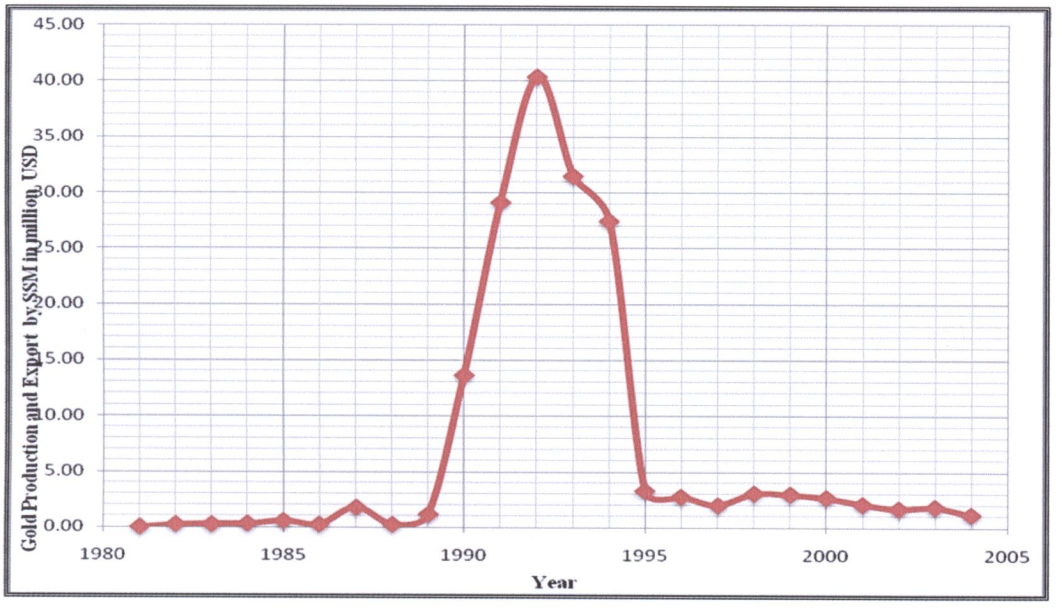


Fig 3.6: Gold Production and Exports by SSM 1981-2005
Source: Ministry of Energy and Minerals DSM, HQ, February 2007

3.6 Infrastructure Development

The discovery of mineral deposits by SSM in different parts of the country has facilitated the development of infrastructure in rural areas. Such infrastructures include roads, electricity supply and telephone communications. For instance,

the road connecting Nyamongo village and Tarime town as well as the road connecting Nyarugusu village and Geita town are clear testimony of these developments.

3.7 Poverty Alleviation in the Rural Population

SSM sub-sector contributes significantly to poverty reduction and eradication among the rural population (Mutagwaba, et al 2004). The SSM sub-sector provides employment to most people living in rural areas where there are no job opportunities in formal employment. The income obtained from informal employment plays an important role in improving the living standards. It also facilitates improving infrastructure such as schools, hospitals, roads, clean water and electricity.

CHAPTER FOUR

SMALL-SCALE MINING AND PROCESSING TECHNOLOGIES

4.1 Gold Mining Technology

The mining operations in small-scale gold mining (SSGM) are heterogeneous and involve several stages depending whether the mineral deposit is alluvial or primary/ reef.

In Geita district (Mugusu, Nyarugusu and Rwamagasa), Musoma district at Buhemba and Masasi in Mtwara region mining centers, the nature of gold mineralization is of primary/reef deposit type.

There are also a few alluvial gold deposits along the riverbank in Rwamagasa and Mugusu mining centers. Mining of alluvial gold deposits involves digging out the mineralized zone using chisels, picks, shovels and hoes while wheel barrows are used as means of transport to nearby washing sites, which in most cases are within or along the riverbank. At Rwamagasa, for instance, the Isilinge River, which is a core source of domestic water for the Rwamagasa community and nearby villages and pours its water in Lake Victoria, has been badly dug-out and silted by SSGM.

However, mining of reef deposits is more labor intensive and demanding than mining alluvial deposits. SSM is more structurally organized in this operation due to the nature of the activities involved and usually mining is an underground operation. There are several stages undertaken in mining primary/ reef gold deposits as observed in Geita, Musoma and Masasi mining centers:

- Drilling blast holes;
- Charging blast holes - primers (detonators and dynamites) are used;

- Loading blast holes with explosives usually dynamites are used though a few advanced SSM use ANFO in addition to dynamites;
- Initiating blast holes- blasting conducted by a holder of blasting certificate issued by the inspector of explosives;
- Ore and waste hoisting from underground using buckets/sisal bags;
- Installing timbers support where applicable; and
- Dewatering the shaft and the workings using buckets and water pump.

4.1.1 Drilling and Blasting

SSM open up a number of shafts within the mining concession (Figure 4.1). These shafts are located following the inclination of the reef. Usually tunnels are mined following the inclination of vein/reef (Figure 4.2). Advanced small-scale miners sink shafts and a series of tunnels intersecting high grade mineralization veins (Figure 4.3). Tunnels are mined with a few support systems in weak zones. The depths of the shafts go to about 70m. At this depth, small-scale miners lack ventilation system because there is no up cast shaft to take out polluted air (Figures 4.2 & 4.3).

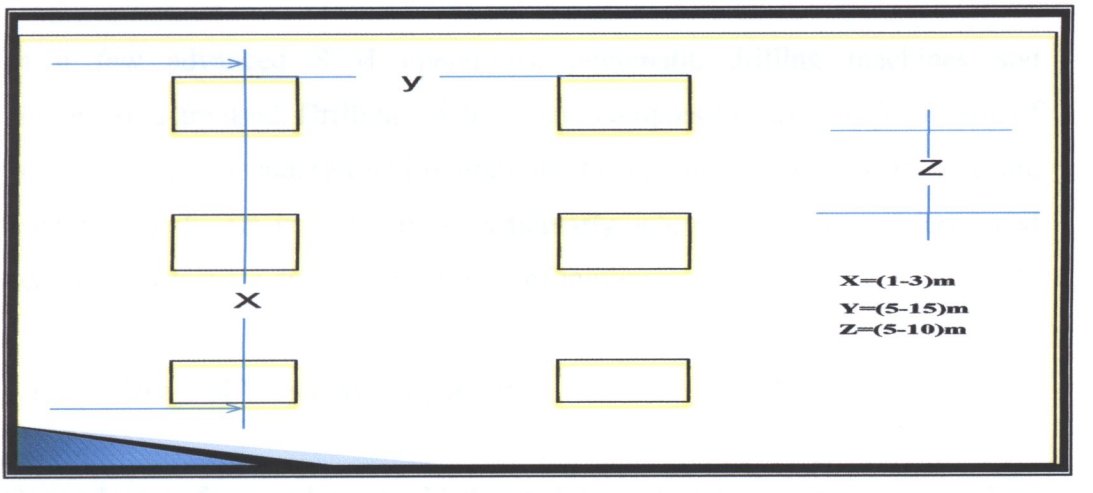


Fig 4.1: A sketch Plan of Shafts in SSGM Concession

Drilling of blast holes is done manually using hammers and improvised iron bars. The depth of holes is less than 1m and the type of the drilling equipment employed influences the hole depth. The number of holes in a blast pattern depends on the dimensions on the working face. In most operations six to eight holes are adequate. For instance at Nyarugusu mining center, the number of holes drilled in one blast pattern is six. Holes are charged with primers (dynamites and detonators) and initiated by a holder of blasting certificate issued by the Inspector of Mines and Explosives.

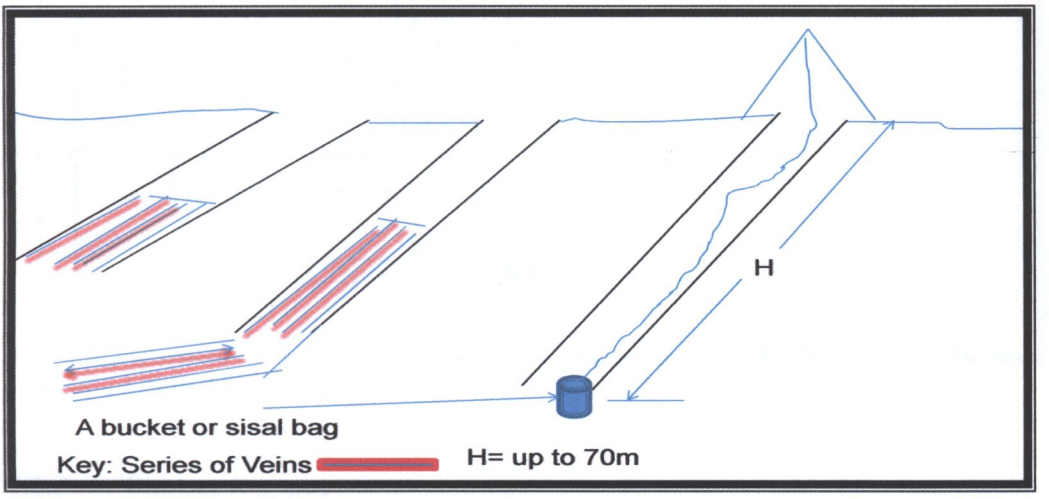


Fig 4.2: A Sketch Showing Mining Sequence in SSGM

In a few advanced SSM operations, pneumatic drilling machines and compressors are used. Drilling machines and compressors are a major reason of noise and dust in underground operations. Furthermore, compressors also are used to supply air in the mines particularly when ventilation underground becomes inadequate due to great depths of mining.

4.1.2 Ore and Waste Management

Ore and waste from underground is hoisted through a shaft using an improvised skip system. A bucket or sisal bag/sack is tied-up to a rope and hoisted to surface through a pulley winding system. Ore is hauled to the processing plant

using donkeys otherwise women are employed to do this job (Plates 4.3 & 4.4). In advanced SSM tractors are used to transport ore to the processing plant or storage facilities. Waste is dumped carelessly outside the shafts' collar. For instance at Mugusu and Rwamagasa, it is common to find piles of waste, debris and rubble adjacent to the shafts' collar. This unplanned and indiscriminate dumping of waste, debris and ruble is a major source of environmental degradation.

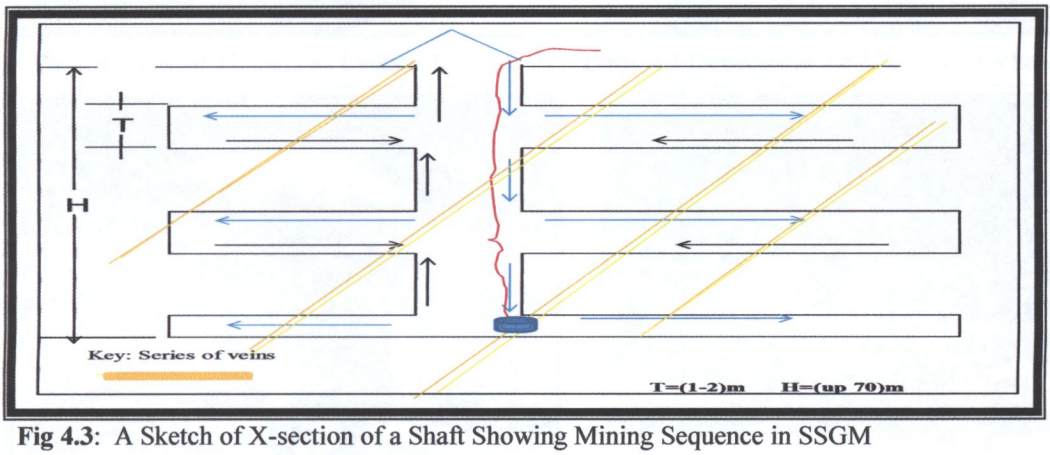


Fig 4.3: A Sketch of X-section of a Shaft Showing Mining Sequence in SSGM

4.1.3 Timber Support

Timbering is done when the ground at the collar, within the shaft or working faces is weak and therefore needs to be supported (Plate 4.1). Timber is also used to construct shelters on top of the shaft to avoid rain water falling directly into the shaft. It also acts as shelter for miners working on the shaft waiting to hoist materials from underground. Timbers also are used to make ladders for access to underground as observed at Rwamagasa (Plate 4.1). The use of timber in SSM however, has aggravated deforestation in SSM.

However, there is also excessive deforestation in illegal mining areas. Indiscriminately felling of valuable indigenous trees to let mining progress is a chief source of tracks of deforestation in illegal mining centers as observed at Buhemba in Musoma rural district.

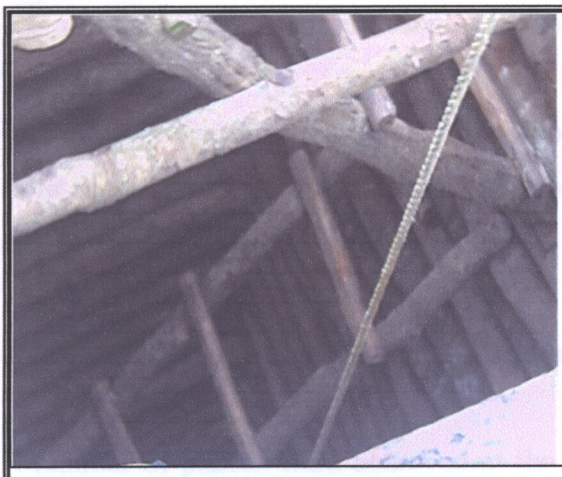


Plate 4.1 Use of Timbers as Ladders in SSM

Plate 4.2 Dewatering the Mines by Buckets

Plate 4.3 A woman Transport Ore in SSM

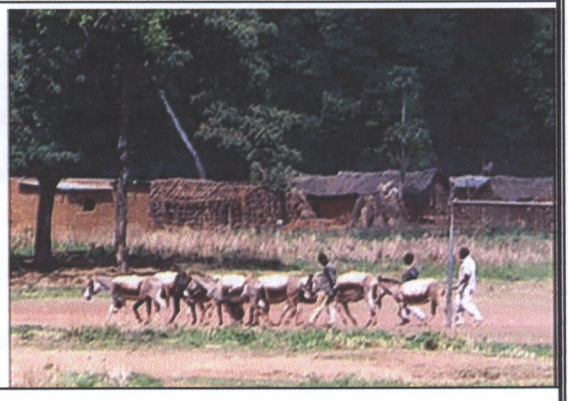


Plate 4.4 Donkeys Transporting Ore at Mugusu

4.1.4 Dewatering the Mines

The water table in the mining centers in Geita district is close to surface from about 10m to 15m and needs constant dewatering for the mining operations to continue. At Mugusu and Rwamagasa, for instance, the water table is closer to surface because of a number of river and stream systems around the mines. Water is the major problem in these mining centers and needs great capital expenditure if an appropriate technology is to be engaged. Water pumps are employed by a few advanced small-scale miners otherwise buckets are used to dewater the mines to let mining and other operations continue (Plate 4.2). This demonstrates the lack of access to appropriate technology such as the use of water pump.

4.2 Processing Technologies in Gold Mining

Numerous processing techniques are employed in gold exploitation. These vary from crude to modern methods and all depend on the knowledge and financial competence of a small-scale miner.

4.2.1 Processing Technology in Alluvial Gold

A number of phases were observed at the Rwamagasa mining center in Geita district near the Isilinge River. These include:

- Manual panning is done along the riverbank to recover alluvial gold;
- Pre-concentration of gold using sluice boxes (Figure 4.4 indicated sluicing) gold being heavier is trapped down on the woolen cloth or a sisal bag aligned on the sluice box to obtain alluvial gold concentrates (Plate 4.8);
- The woolen cloth or sisal bag is then washed comprehensively in a pan to obtain gold concentrates (Plate 4.9);
- Amalgamation process where mercury is added to gold concentrates to obtain gold-mercury amalgam (Figure 4.4 indicated amalgamation). The mixture is stirred comprehensively to ensure that all gold particles are absolutely amalgamated by mercury (Plate 4.10). The mixture is then washed by panning to separate gold amalgam and tailings. The amalgam is then wrapped in a soft cloth and squeezed to remove excessive mercury; and
- The amalgam is burnt off using a retort to separate gold and mercury (Figure 4.4indicated retorting).

4.2.2 Processing Technology in Primary/Reef Gold

Generally the processing phases for primary gold in different mining centers are the same as observed at Nyarugusu, Mugusu, Rwamagasa and Masasi. Some similarities also were observed at Buhemba mining centers where illegal

mining was in progress. The processing phases undertaken are shown in the flow chart (Figure 4.4) and comprehensively described in the subsequent sections.

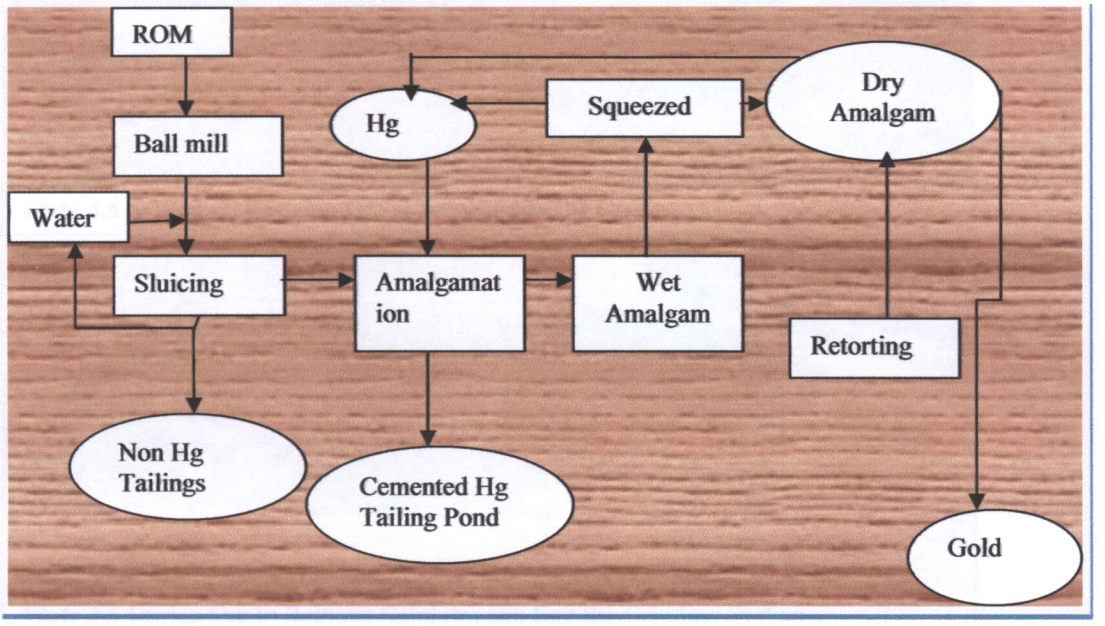


Fig: 4.4 A Flow Chart Showing Processing Phases in SSGM

4.2.2.1 Ore Sorting, Drying and Resizing

- Sorting of rich ore is done immediately at the mine site before ore is transported to the processing plant for processing or storage purpose;
- Ore is resized manually using a hammer to suit the grinding system; usually women are employed in this activity (Plate 4.5);
- Ore is dried before it is crushed to remove excessive sulphites, which is the main barrier in gold recovery using mercury as well as for compatibility reasons because the grinding system available requires dried ore as observed at Mugusu, Nyarugusu and Rwamagasa mining centers in Geita district (Plate 4.6).

Plate 4.5 A Woman Resizing Ore at Mugusu **SSGM** Center

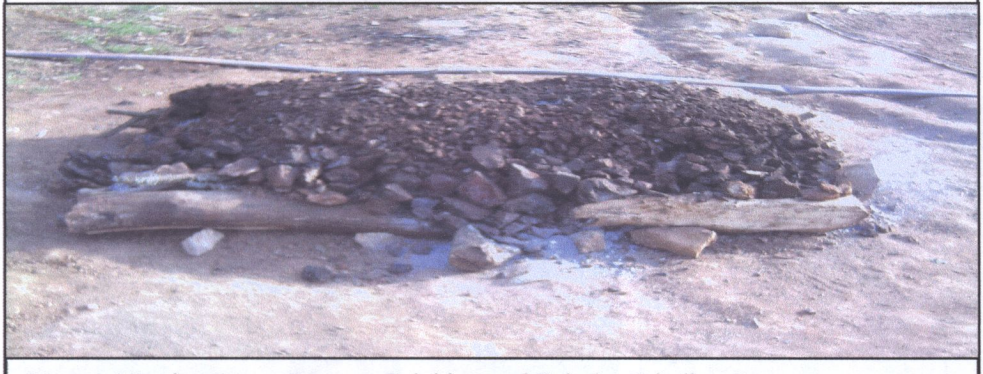


Plate 4.6 Drying Ore to Remove Sulphites and Suit the Grinding System

4.2.2.2 Ore Grinding

Two grinding techniques were observed in SSGM centers in Geita and Musoma and these are:

Ancient Grinding Method: The ancient grinding technology is done in a wooden mortar with an axle as a pestle to transform ore into powder. Dust and noise are the major environmental problems at this stage. Miners rarely use personal protective equipment (PPE) against dust and noise generated by the system. The technique is mainly used by illegal miners because of their legal status they cannot establish appropriate technology.

Ore Grinding Using a Ball Mill: Different capacities of ball mills are used in SSGM centers in Tanzania. The capacity of a ball mill depends on the hardness

of feed, product size and the size of the available balls. The Ball mills are powered by diesel generators and they operate with cast or forged steel balls (Plate 4.7) (Figure 4.4 indicated ball mill). The capacities of mills employed in SSGM range from 5t/24h to 15t/24h with their sizes at 60cm× 90cm to 90cm× 120cm and run at speeds of between 32 and 43 rpm respectively. The ball mill grind ore to powder particle size < 150μm as observed in SSGM centers at Mugusu, Nyarugusu and Rwamagasa in Geita district.

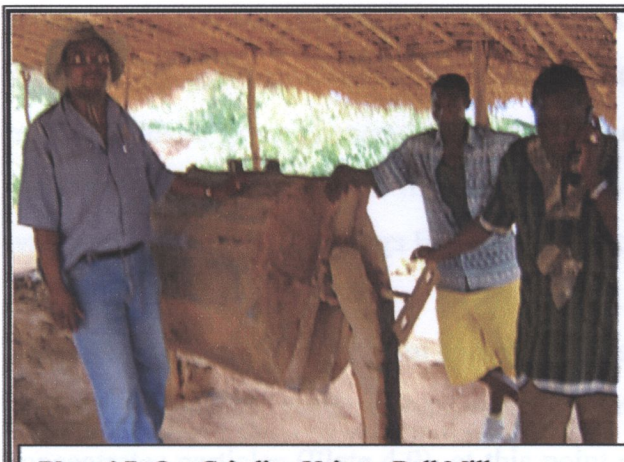


Plate 4.7: Ore Grinding Using a Ball Mill

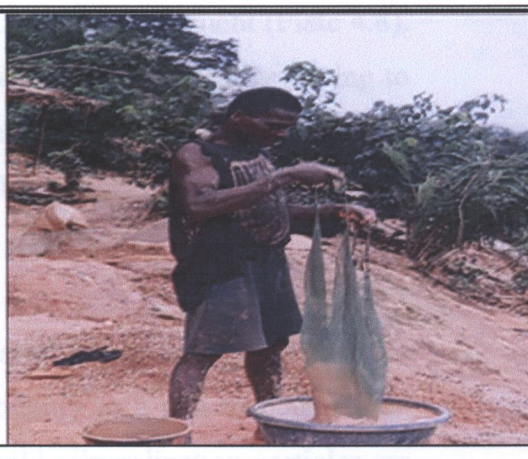


Plate 4.9: Gold Particles Washing at Mugusu

Plate 4.8: Gold Pre-concentration at Mugusu

Plate 4.10: Gold Amalgamation at Mugusu

The second technology is also being employed by illegal miners as observed at Buhemba mining center in Musoma rural district where illegal gold mining was found in progress. Miners were not using PPE against noise and dust generated and they are subjected to chronic health diseases like TB and silicosis.

4.2.2.3 Pre-concentration of Gold

This is a pre-concentration stage of reef or alluvial gold. A woolen cloth or a sisal bag is aligned on the sluice box to trap gold mineralized particles (Figure 4.4 indicated sluicing). Pouring of powdered ore in the sluice box and water are done simultaneously. Consequently, gold being heavier is trapped down on the sisal or woolen cloth (Plate 4.8).

Tailings are dumped carelessly within the surrounding environment (Plate 4.8). A few advanced small-scale miners keep their tailings in the vicinity hoping to re-process them given changes of processing technologies. For instance, during the field study at Nyarugusu mining center, a heap leaching processing plant was seen re-processing tailings from small-scale miners.

Once all powdered ore has been completely washed down on a sluice box, the sisal bag or woolen cloth is then washed thoroughly in a pan to obtain gold concentrates particles (Plate 4.9), at this point gold mineralization particles are read for amalgamation.

4.2.2.4 Gold Amalgamation

Mercury is added at this stage to obtain a gold mercury (Au-Hg) amalgam (Figure 4.4 indicated amalgamation). The mixture is stirred thoroughly to ensure that all gold particles are absolutely amalgamated by mercury (Plate 4.10). The mixture is then panned systematically in a washing pan to recover the wet gold-mercury amalgam. The amalgam is then wrapped in a piece of cloth and squeezed to remove excessive liquid mercury.

Gold processing phases are done within cemented washing tailing ponds controlled circuit to avoid mercury disperse to the rest of the environment. The tailings contaminated with mercury are securely stored in cemented tailings

dumps as observed at Mugusu, Rwamagasa and Nyarugusu mining centers to ensure there is no contact with the rest of the environment.

4.2.2.5 Gold Amalgam Retorting

The amalgam is burnt to separate mercury and gold using a retort (Figure 4.4 indicated retorting). SSGM at Mugusu, Nyarugusu and Rwamagasa were seen using retorts to recovery both gold and mercury. The recovered mercury could be used in another amalgamation process.

However, illegal miners at Buhemba were seen amalgamating and burning their amalgam in open air subsequently releasing a lot of liquid and vapour mercury into the environment. Furthermore, the burning of the amalgam takes place in gold dealers' shops where more mercury in the form of vapor is excessively released into the environment. Miners are at risk of being exposed to the hazardous poisonous mercury.

4.3 Gemstone Mining and Processing Technologies

Mining of gemstones mostly do not require the use explosives because mining is done within or along riverbanks and riverbeds or in soft gravels where the use of chisel, picks, shovel and hoes is adequate. However, most gemstone mining centers in Mbinga district is managed and conducted by illegal miners who escape the hands of law. The mining phase is labour intensive because of the nature of the mining tools employed.

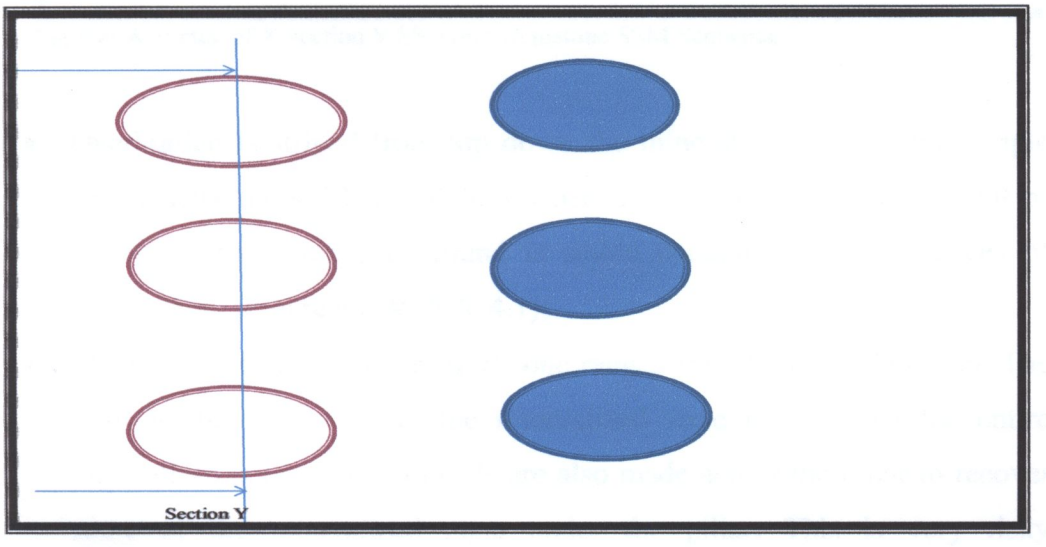


Fig 4.5: A Plan of Pits in Gemstone SSM Centers in Mbinga District

4.3.1 Gemstone Mining in Gravels and Soft Materials

Gemstone mining operations at Ngembambili, Masugulu and Mkako involves, mining of the mineralized zone using rudimental tools. Mining of gemstone from gravel soft materials undergoes the following phases:

- Clearing off all vegetations within the area of interest to allow enough space for men working;
- Numerous pits are opened in the mining concession (Figures 4.5 &4.6);

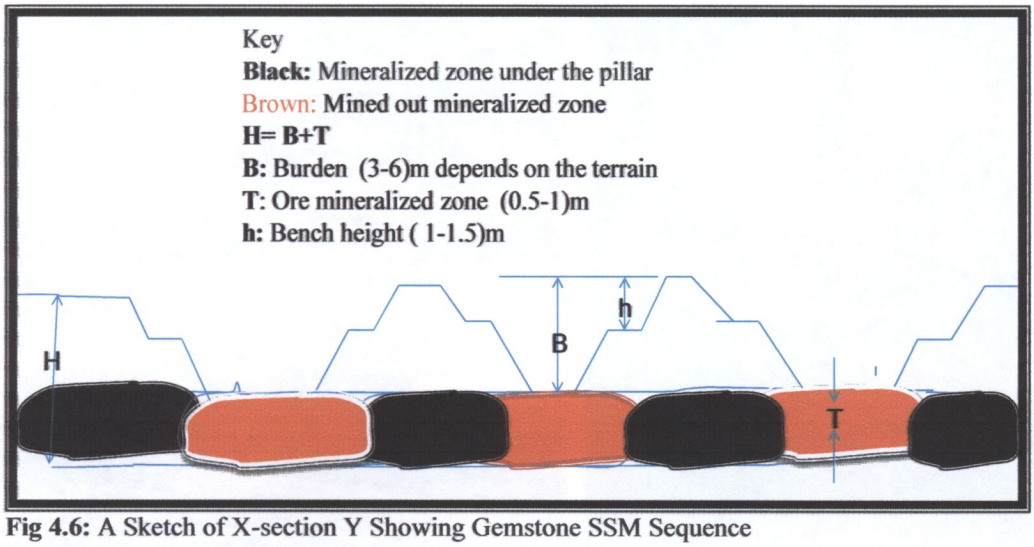


Fig 4.6: A Sketch of X-section Y Showing Gemstone SSM Sequence

- Overburden is striped from top down the mineralized zone using simple rudimentary tools. This is done on bench style with the bench height of about 1m to ensure the ground is stable enough for falling pieces of overburden (Figure 4.6 & Plate 4.1);
- The thickness of the mineralized zone ranges from 0.5m to about 1m. The shaft is then sunk within the mineralized zone to mine-out the entire mineralized zone. A few tunnels are also made across the pillar to recover some of the mineralized zone under the pillar. This is very risky considering the ground is usually weathered (Figure 4.6);
- Men arrange themselves from down the pit to surface to move out waste and ore to surface using buckets or pans (Plate 4.11);
- Waste is dumped carelessly in the mining concession as shown at the background of Plate 4.11;
- Mined mineralized material is transported to the nearby processing site, which in most cases, is along the riverbank; and
- Illegal miners do not mine on benches style because of their legal status resulting in numerous collapsing pits, which are a major factor contributing to mining accidents in illegal mining areas;

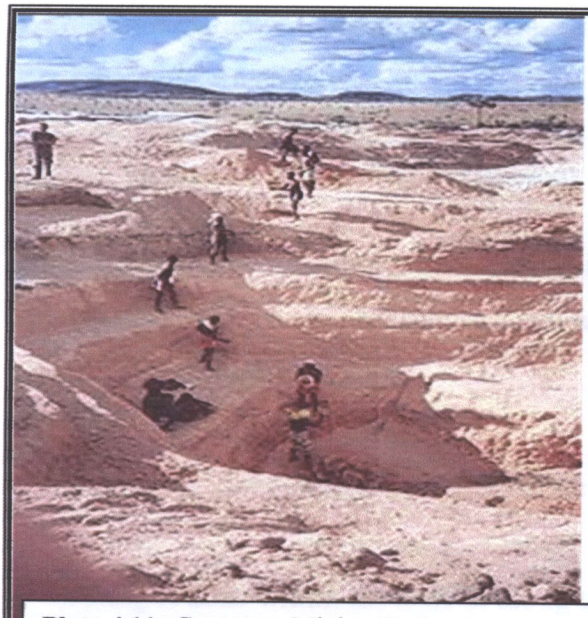


Plate 4.11: Gemstone Mining Technology

Plate 4.12: Gemstone Processing Technology

4.3.2 Gemstone Mining in Streams and Rivers

Gemstone mining in stream and river systems involves the use of simple mining tools such as picks, hoes and shovels:

- Stream or river water is deviated from its original channel to allow mining progress;
- By using shovels and picks riverbeds and riverbanks are completely dug-out to remove gravel materials from the riverbeds where gemstones are believed to have settled;
- Waste is dumped within the river and stream system;
- The mined out gravel is transported to the processing sites;
- The carrying capacities of river and streams are subsequently reduced due to a number of left-out dug-outs and mounting dumped waste, rubble, debris and tailing. As a result floods can occur during heavy rains. The dug-outs and the mining wastes are the major environmental problems from these operations; and

- The mining activity is labour intensive and therefore requires many people to be done effectively.

4.3.3 Gemstone Processing Technology

Numerous phases are involved in processing of gemstones as observed in Mbinga district at Mkako, Masugulu Lindi and Ngembambili gemstone mining centers. These phases include:

- Sieving is done manually to separate soft soils, gemstones and other gravels;
- Sifting is done within the river or along the riverbank (Plate 4.12);
- The resulting waste, debris, rubble, tailing and the washing waters are pumped back in river or stream systems resulting in blockages and siltation. This is one of the major environmental problems resulting in gemstone mineral processing activities; and
- Sorting the variety of gemstones in terms type, size, grade and quality.

Siltation, sedimentation, diverted water course, abandoned pits, shafts, wastes and tailings are the major factors contributing to environmental degradation in gemstone SSM.

CHAPTER FIVE

ENVIRONMENTAL DEGRADATION

5.0 Introduction

The "Environmental Degradation" in this context is explicitly defined as the environmental adverse effects resulting from application of poor mining and processing practices. Other additional contributing factors include the inadequacy of the institutional and legal framework to effectively administer the sub-sector, lack of funding to facilitate access to appropriate technology.

The environmental degradation in SSM ranges from land destruction and ecosystems to health risks to the living organisms. The major environmental degradations resulting from SSM activities as a result of application of inappropriate technologies are catalogued and discussed in the subsequent paragraphs under two mineral commodities due to their diversity.

- Gold mining and processing activities; and
- Gemstones mining and processing activities

5.1 Gold Mining and Processing

The major environmental degradations observed in gold mining centers as well as those established in the application of mining and processing technologies are catalogued and discussed in the subsequent paragraphs.

5.1.1 Deforestation

The indiscriminate cutting down of valuable trees by SSM is a common problem experienced in gold mining centers visited. For instance, most valuable

trees and shrubs at Mugusu and Rwamagasa have been completely eliminated by SSM to let mining progress. The nature of operations of most small-scale miners is the major reason of a number of tracks of deforestation in most mining centers. There are several reasons why miners cut and clear sites.

- Opening up new shafts and pits to let mining progress;
- Timber for support purposes;
- Construction of shelters and dwellings;
- Making processing tools such as sluice boxes;
- The source of heat to dry up reef gold ore because the available grinding systems require dry ore and for domestic uses.

For instance, Plate 5.2 shows the land, which was fully vegetated has been cleared by SSM for mining and other purposes. As can be seen from the background of the photo the land has been left bare making arable land useless for other economic activities such as farming and livestock raring.

5.1.2 Land Degradation

SSM involves opening up pits, shafts and trenches haphazardly using crude and rudimentary equipment. For instance at Mugusu, Nyarugusu and Rwamagasa, there are numerous abandoned shafts, trenches and pits all over the mineral concessions (Plates 5.1 & 5.2).

Despite the fact that small-scale miners are obliged by the Mining Regulation of 1999 to backfill or fence abandoned workings, this is not the case as this is regarded as an additional cost in their operations which does not bear any return in the whole operation. The mineral concessions are full of pits, shafts and trenches which make them death traps to the miners and other land users like farmers and cattle keepers (Plates 5.1 & 5.2). Heavy rains result into dug-out areas to being transformed into stagnant ponds, which are breeding grounds for

mosquitoes exacerbating the problem of Malaria. A few advanced small-scale miners like Kadeo Mining Enterprises at Rwamagasa mining center open up shafts and pits systematically and backfill the same after mine closure for safety and environmental reasons prior to opening new ones.

None of the SSGM centers visited had environmental management plan. This is partly due to the fact that, the Mining Regulations of 1999 and amended in 2004 governing environmental standards requirements for SSM does not oblige them to this requirement. Mining activities are done by combined exploration and mining operations with their associated environmental degradations.

None of the SSM centers visited had waste dumping areas in their mineral concessions. A few miners at Mugusu and Rwamagasa were seen back filling the mined-out shafts and pits using wastes.

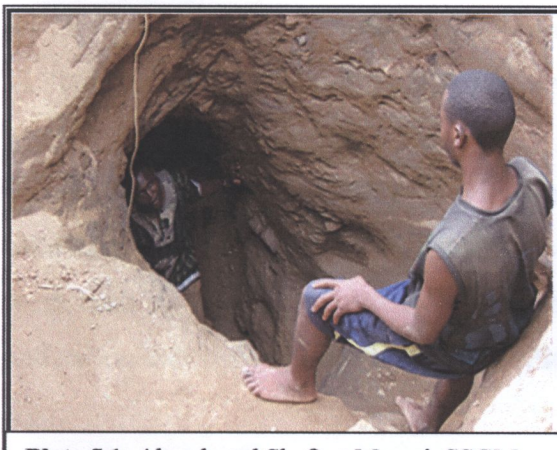


Plate 5.1: Abandoned Shaft at Masasi SSGM

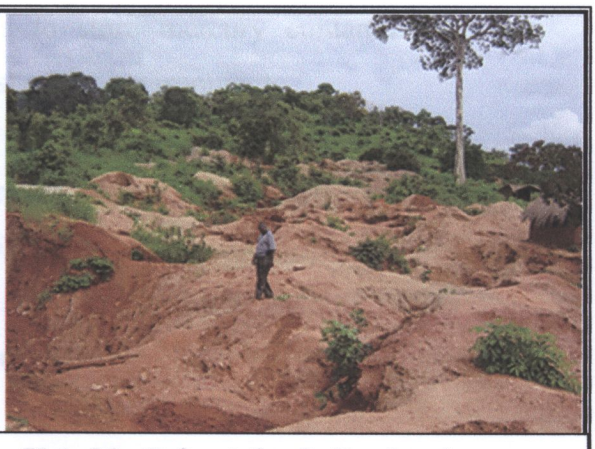


Plate 5.2: Deforestation & Abandoned Workings

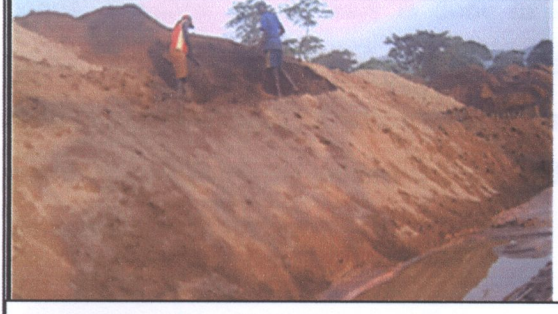


Plate 5.3: Piles of Tailings at Mugusu SSGM Center

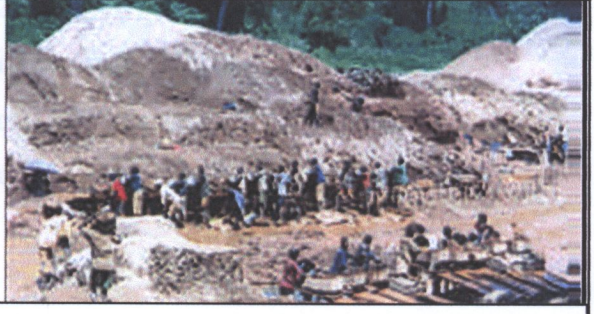


Plate 5.4: Siltation of River Due to Gold Sluicing at Mugusu SSGM Center

The piles of waste, debris, rubble and tailing are the major sources of environmental degradation observed in SSGM resulting in the arable land becoming useless for other economic activities.

Most SSGM centers have constructed washing and settling ponds in their mining concessions. This is due to the fact that, operating conditions in gold mining centers are very strict because of the use of the poisonous mercury in gold recovery. Two types of tailings dumps were seen in gold mining centers:

- Large tailings dumps to store non-mercury contaminated tailings (Plate 5.3). These tailings are kept with the hope of re-processing them in the future with improvement in recovery technologies. In some mining centers, non-mercury contaminated tailings especially those from alluvial deposits assuming that there is no more gold mineralization are dumped carelessly in nearby surroundings; and
- SSM use cemented constructed ponds to store mercury contaminated tailings to avoid contamination of the rest of the environment.

Washing and settling tailing ponds were seen to have limited carrying capacities to accommodate large quantities of tailings. Some small-scale miners wash their minerals within the river system. Tailings, rubbles, washing waters and debris are then dumped in the river (Plate 5.4).

However, it was observed that illegal miners do not have washing and settling ponds. Washing of minerals is done in some existing river systems and all rubble, washing water and tailing are dumped back in the river systems resulting in blockages of water bodies. As can be seen (Plate 5.4), miners are washing their minerals within a river and all tailings are eventually dumped back in the river system.

5.1.3 Mercury Exposure in Gold Recovery

Mercury emission into the ecosystem has been one of the global problems in developing countries where SSGM operation is the major livelihood activity. SSGM emits mercury into the environment during gold amalgamation and amalgam retorting. Small-scale miners in Geita mining centers were seen using constructed cemented washing and settling ponds to store mercury contaminated tailings to ensure that mercury is not discharged into the rest of the ecosystem. Retorts also were being used in burning the amalgam to separate mercury and gold and mercury can be re-used in subsequent gold recovery.

The introduction of locally made iron retorts has brought relief to most small-scale gold miners because retorts are now available in local markets at affordable prices. However, since iron made retorts are not transparent, small-scale miners cannot see what is going on during amalgam retorting and the resulting amalgam is dark and does not attract good price.

The outreach training programmes conducted by the Government and by a few NGO's in a number of SSGM centers on how to handle and use mercury has however substantially reduced mercury dispersion into the environment.

The emission of mercury into the ecosystem is rampant in illegal gold mining centers. At the Buhemba mining center for instance, illegal miners have encroached a LSM and were seen amalgamating gold without using gloves and burning the same in open air. Miners are subjected to health risks because of poisonous mercury.

The environmental concern for the toxic mercury metal in illegal mining areas is evident given the past occurrences of the *"Minamata disease"* in Japan and numerous cases of mercury poisoning in developing countries (Noetstaller, 1997). The literature emphasizes five classical symptoms of mercury poisoning,

which are the major concerns of small-scale gold miners in the mining centers visited. There are five classical symptoms of mercury poisoning, which include Visual constriction, numbness of the extremities, impairment of hearing, impairment of speech and impairment of gait (Noetstaller, 1997).

However, there is still also a large group of illegal miners in other mining centers who still use mercury rampantly and this has been accelerated by numerous gold discoveries particularly in the LVGF. Illegal gold miners do not use protective gears because of their legal status.

5.1.4 Siltation, Sedimentation and Deviation of Surface Water Sources

When mining is carried out on hills and slopes, severe erosion takes place and flooding can result. In certain locations, small-scale miners not only remove vegetation and economically valuable trees but their activities also divert surface drainages.

Rwamagasa and Mugusu mining centers in Geita district, for instance, are closer to the river systems and are within the most sensitive ecological area of the LVGF. The Isilinge River at Rwamagasa has been completely dug-out and silted by small-scale miners. Washing of minerals is done within or along the riverbanks resulting in siltation and sedimentation. Piles of tailings, silts and sediments from gold pre-concentration are eventually dumped within the river system as observed at Mugusu and Rwamagasa mining center (Plate 5.4.)

Rivers and streams systems in most illegal mining activities are heavily subjected to siltation and sedimentation. This is due to the fact that mining is done along riverbanks and within riverbeds at the same time all minerals processing phases are done within the river systems. For instance, a small stream existing across the Buhemba mining center where illegal mining was found in progress has been completely silted because of washing of minerals.

This stream is the source of domestic water for the community living within the Buhemba mining center as well as nearby villages. The stream pours its water in Mara River, which is the major tributary of Lake Victoria.

5.1.5 Smoke and Dust

Smoke is generated whilst drying reef gold ore by burning the logs together with the ore to liberate excessive sulphides. The presence of sulphides is the main barrier in gold recovery using mercury. Similarly, the grinding system available requires dried ore. Dust also is generated during blast operations, ore and waste handling and during the grinding phase and is the major source of chronic diseases such as TB and silicosis if health precaution measures are not taken care off.

5.2 Environmental Degradation in Gemstone Mining and Processing

Fourteen mineral right concessions, mining varieties of gemstones particularly sapphires, were visited in Mbinga District. The rest of the mining concessions within are operated by illegal miners scattered throughout a series of available river and stream systems. Gemstone mining and processing phases result in a number of environmental degradation as catalogued and discussed in the subsequent sections.

5.2.1 Deforestation

There are a few licensed small-scale gemstone miners in Mbinga District at Ngembambili and Masugulu mining centers. Mining of gemstone is conducted in the existing stream and river systems and in gravel soft land. A series of phases are undertaken including felling and digging out valuable indigenous trees to let mining progress is a common environmental problem in gemstone SSM centers.

However, most tracks of deforestation are found in illegal mining centers as most gemstones mining activities in Mbinga District are operated by illegal miners. Illegal mining centers range from Ngembambili, Masugulu, and Mkako to Mkeso.

Gemstone mining involves felling and digging out valuable trees and shrubs for a number of reasons, the major ones being:

- Opening up new shafts and pits to let mining progress;
- Timber for support especially when mining is done in soft gravel ground;
- Source of heat for domestic use;
- Construction of shelters and dwellings; and
- Making processing tools such as gemstone sifting boxes.

Most of these tracks of deforestation were found at Masugulu, Mkeso and Mkako where a series of illegal gemstone mining centers have been established. Miners fall valuable trees using pangas and dig-out trees using hoes and shovels to have access to land for mining. As the results most of the arable land has been turned into pot holes and barren land. This has resulted in clashes between miners looking for minerals in a number of forests and river systems and farmers on the other hand looking for pastures for their animals. Felling and chopping down valuable indigenous trees is the major factor contributing to deforestation in gemstone SSM centers.

5.2.2 Land Degradation

Mining of gemstone involves digging shafts and pits using rudimentary simple tools, such as hoes, shovels and chisels resulting in numerous workings within the mining concession. There are no reclamation programmes set aside in most gemstone small-scale mining centers visited. This has resulted in a number of abandoned shafts, pits, trenches and other dug-outs all over the mining

concessions as observed at Masugulu, Mkeso and Mkako (Plate 5.6). Fencing or backfilling of mined-out shafts and pits is never done at all as it is considered as an additional cost in the operations. Heavy rains result in dug-out areas to be transformed into stagnant ponds which become breeding grounds for mosquitoes and other water born diseases.

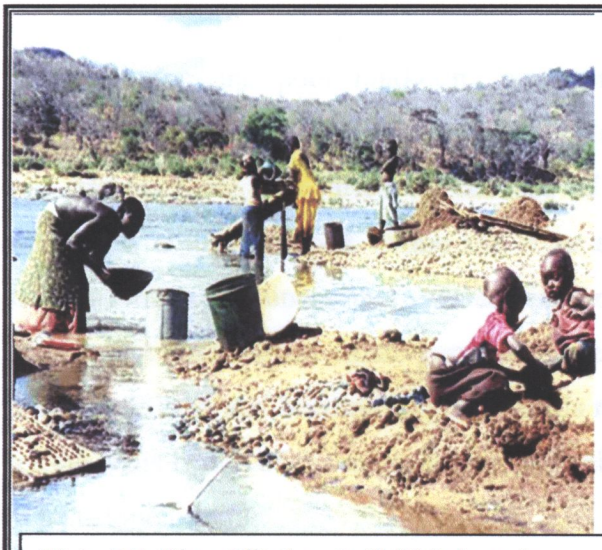


Plate 5.5: River Siltation & Child Labour in Gemstone SSM

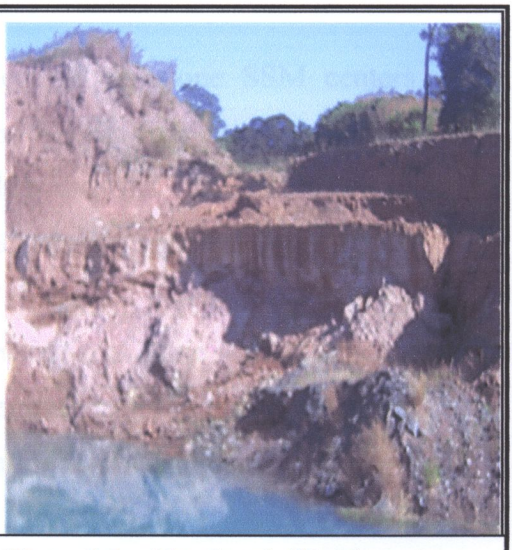


Plate 5.6: Abandoned Workings in Gemstone SSM

In small-scale mining gemstone centers visited, none of the miners had an environmental management plan. Mining of gemstones is carried-out within a number of existing streams and rivers as well as in soft gravel ground. Waste from the mines and tailings from processing sites are dumped carelessly within the mining concessions. Rivers and streams have been diverted by numerous dug-outs and silted with sediments, which has resulted in river blockages affecting community living downstream (Plate 5.5).

Small-scale miners in gemstone mines have no specific waste dumps in their mining concessions. Waste is carelessly dumped in the mining concessions. It is common to find huge piles of waste along riverbanks where washing and sifting of gemstones is done, which have resulted in siltation and sedimentation of river systems (Plate 5.5).

Abandoned workings (pits, shafts, and other dug-outs), piles of waste and tailing, riverbank and riverbeds destruction and siltation are the major contributing factors to environmental degradation in gemstone mining centers. Consequently, this has made the arable land become useless for other economic activities like farming and livestock raring resulting in daily clashes between miners and farmers.

Illegal mining and poor marketing arrangement in gemstone SSM centers (Sapphires particularly at Masugulu, Mkeso and Mkako) are rampant. Rivers and streams have been dried up because of dug-outs and mounting piles of waste and tailing dumped within the river and stream systems. In dried up streams and rivers miners have created series of shafts and pits with the river by digging-out the riverbed where gemstones are believed to have settled. Pits are never backfilled and become stagnant ponds resulting in flood during the rainy season. This is one of the major factors contributing to environmental problems in gemstone mining.

Illegal miners have also created series of swamps in the middle of the dried up river system and trap water from other tributary streams for washing their minerals. All waste, rubble, debris, tailing and the washing water from mineral processing are eventually dumped in the river and stream systems resulting in sedimentation, siltation and blockages of river and stream systems there by denying to other water users living downstream.

5.2.3 Siltation, Sedimentation and Deviation of Surface Water Sources

When mining is carried out on hilly and sloppy areas, severe erosion takes place and flooding can result due to blockages of water system. In certain locations, miners not only remove vegetation and economically valuable trees but their activities also divert surface drainage systems. For instance, at Masugulu, Mkako and Mkeso mining and washing of gemstones is done within

a series of available river and stream systems (Plate 5.5) resulting in siltation and sedimentation. Some of the streams and rivers have dried up because of huge piles of waste and tailings dumped in them. There are always clashes between miners and other land users like farmers and cattle keepers, who depend on these streams for domestic water and for their animals.

The Ngembambili River has been silted by illegal miners since 1993 when sapphire was first discovered. River Ngembambili is the major source of domestic water to the communities living within the mining centers and act as the catchment area for the Ruvuma River, which pours its water in the Indian Ocean. The breeding grounds for fish and other aquatic organisms within the Ngembambili River have been completely destroyed.

In Mbinga district, there are a lot of illegal gemstone mining centers mining particularly for sapphires. Mining is done within rivers, streams and soft gravel where gemstones are believed to have settled. Washing and sifting is done within rivers and streams and all tailing, debris, waste and washing waters are eventually dumped in them (Plate 5.5)

Miners were seen diverting the Ngembambili River to give way to mining at the riverbed where it is believed that heavier gemstones could have settled. Rivers and streams have been dug-out and silted by illegal miners and this is one of the major environmental problems to being faced by the communities living downstream.

CHAPTER SIX

IMPACT OF INSTITUTIONAL AND LEGAL FRAMEWORKS

6.1 Institutional Framework

To ensure the mineral sector is properly managed, the government has undertaken a number of measures as outlined in the subsequent sections.

6.1.1 Mineral Resources Department (MRD)

The Government has been restructuring, streamlining and strengthening the administrative and organizational framework of the MRD to properly and effectively administer, promote and service the mineral sector particularly the SSM sub-sector. There are two assistant commissioners and seven sub-sections within the MRD at the ministry' head quarters and are part of the combined institutional force to effectively administer the mining industry. These sub-sections include; Chief Inspector of Mines (CIM); Head of Coordination and Extension Services (HCES); Head of Environment (HEM); Head of Explosives (HEX); Head of Promotion and Statistics (HPS); Head of Legal and Policy (HLP); Head of Licencing and Mineral Right (HLMR) (Figure 6.1).

6.1.2 Environmental Sub-section

The establishment of the Environmental sub-section (HEM) within the MRD is one way forward that the Tanzanian Government needs to be commended for. The sub-section is responsible, among other things, for overseeing all environmental related issues in the mining industry, for both LSM and SSM sub-sectors. Furthermore, the environmental sub-section is the major link between the Ministry and other Governmental organs such as the National Environmental Management Council (NEMC), Ministry of Environment and the rest of other mining players.

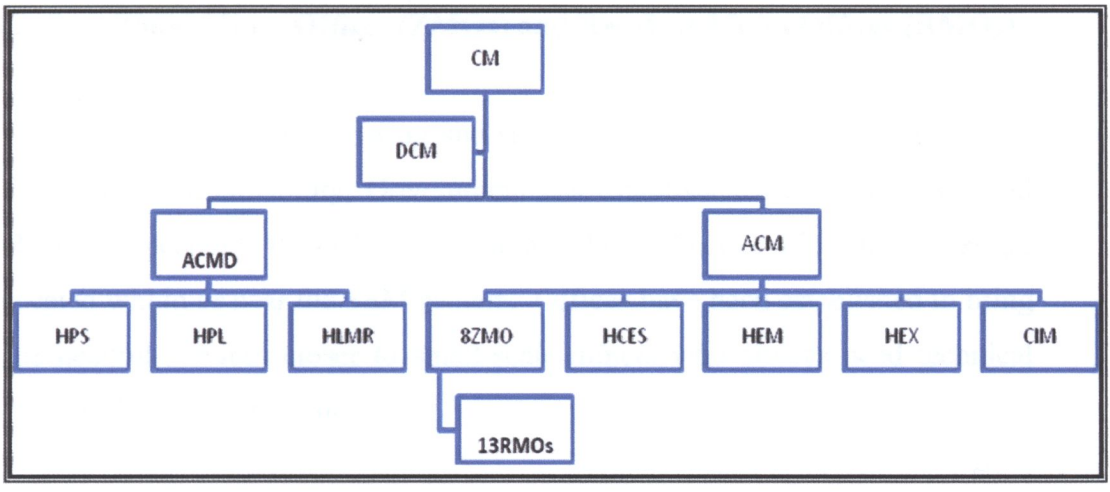


Fig 6.1: The Current MRD Institutional Framework Structure
Source: Ministry of Energy and Minerals, HQ, DSM Feb 2007

6.1.3 The Coordination and Extension Services Sub-section

The establishment of the coordination and extension services sub-section (HCES) in MRD has facilitated coordination of the ZMOs and RMOs countrywide (Figure 6.1). Furthermore, the sub-section is responsible for coordinating training arrangements and extension services for SSM in collaboration with the ZMOs. Training on good mining and processing practices instill a sense of awareness among SSM thereby enhancing environmental protection and Government revenue.

6.1.4 The Mines Inspectorate Sub-section

The setting up of the Mines Inspectorate sub-section led by the Chief Inspector of Mines (CIM) (Figure 6.1) has enhanced, among other things, inspection, monitoring, and institution of legal requirements for non-compliance. Instituting legal requirements among the SSM helps to change the mining and processing practices and enhance environmental protection in SSM sub-sector.

6.1.5 Zonal Mines Offices (ZMOs) and Resident Mines Offices (RMOs)

SSM is one of the fast growing sub-sectors of the economy in Tanzania. To facilitate its sustainability, Government has established 8 and 13 ZMOs and RMOs, respectively throughout the country (Figures 6.1 & 6.2). The offices are located within or near the SSM centers. Offices have been established to bring the needful services closer to small-scale miners who always need technical support from Government.

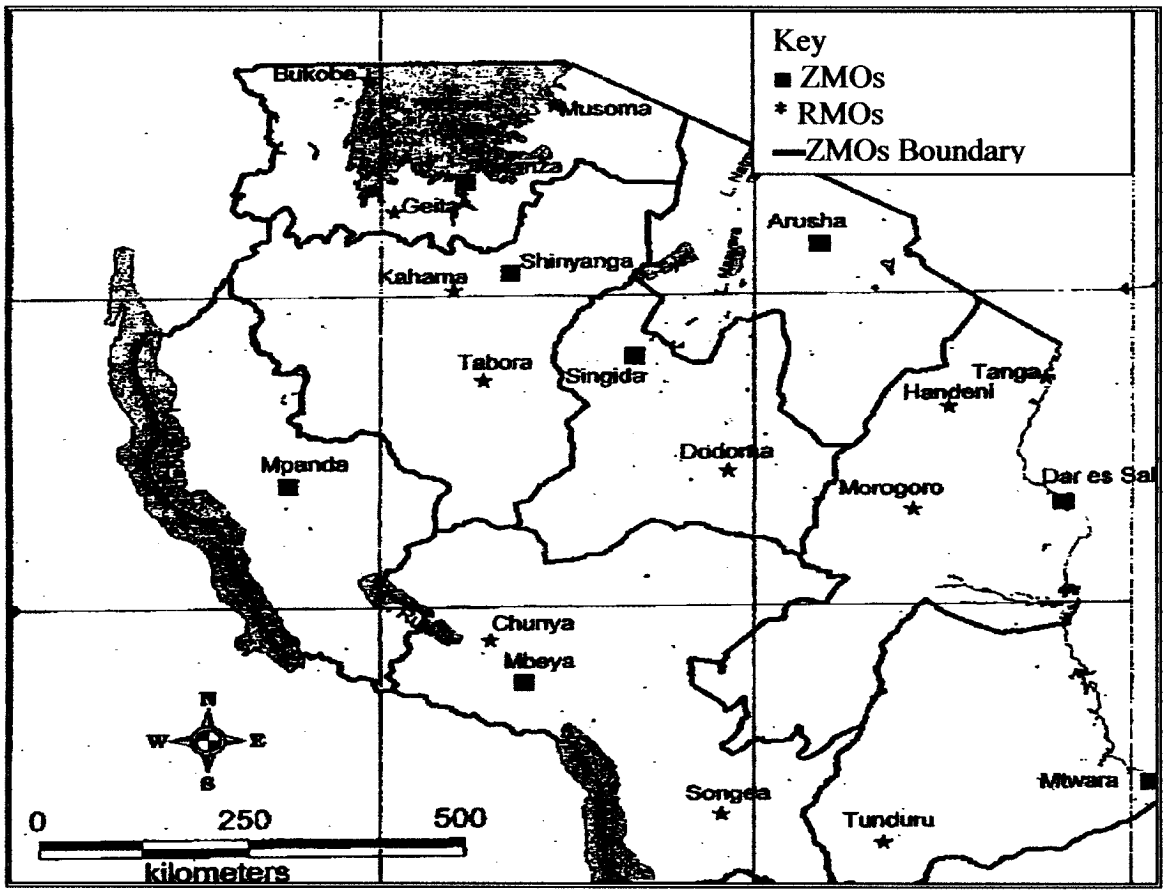


Fig 6.2: Distribution of ZMOs and RMOs in the Country
Source: Ministry of Energy and Minerals, February 2007, Dar-es-salaam, Tanzania

The ZMOs/RMOs are responsible, among other things, coordinate and provide extension services to small-scale miners with regard to:

- Good mining and processing practices, which are environmentally friendly for sustainability of the sub-sector;
- Safety standard requirements among SSM; and
- Marketing arrangements and saving measures to mention but a few.

One of the significant contributions of ZMOs and RMOs is the decentralization of the issuance of primary mining and mineral marketing licenses to small-scale miners. This has significantly facilitated legalization of many illegal miners country wide which has enhanced compliance to good mining practices adhering to some acceptable environmental standards.

6.1.6 Communication Facilities in MRD

Government has strengthened communication and the flow of information among the Ministry's head quarters, ZMOs and RMOs. Some of the communication facilities set up to enhance information flow include:-

- Internet connectivity to all ZMOs and RMOs.
- All offices are networked with telephone and fax; and
- Strengthened workers with computer literacy.

6.1.7 Mining Cadastre Information Management System (MCIMS)

MCIMS is a tool in improving the administration of mineral rights in the country. MCIMS has made it possible for the licensing procedure to be more open and realistic. The principle of first come first serve has eliminated the complaints of bureaucracy and corruption in the system especially the licensing procedure for small-scale miners. The system has facilitated legalization of a number of illegal miners who contribute greatly to the environmental degradation.

6.1.8 Radio and Television Programmes

Small-scale miners at Mugusu and Nyarugusu mining centers visited are aware of the environmental awareness campaign being broadcast through television and radio. This is one of the Government strategies to facilitate provision of useful information to the SSM sub-sector as stipulated in the Mineral Policy 1997. The Ministry of Energy and Minerals (MEM) initiated radio and television programmes in order among other things, to sensitize small-scale miners and other stakeholders on the environmental awareness issues in the country, which include management, conservation and protection.

6.1.9 Strengthening Mining Learning Institutions

Government has strengthened the Madini Mining Training Institute in Dodoma, which used to offer certificates in mining related fields. Currently the institute is offering training in relevant mining related fields at diploma level (geology, mining, metallurgy and environment) as compared to the past five years. This institution also offers short courses for small-scale miners in a number of fields including, mineral prospecting, mining, safety, health and environmental issues.

The DSM Institute of Technology (DIT) also is offering training in mining-related courses at diploma level.

The establishment of Department of Mining Engineering at the University of DSM needs to be treasured. Currently the department is offering bachelor of mineral science in mining engineering.

These are clear positive indications that Government is facilitating the growth of the mining industry particularly the SSM.

6.1.10 Technology Transfer to SSM

The Government through MEM has undertaken a number of projects to assist SSM in terms of technology transfer. These include the establishment of SSGM and extraction technology demonstration plant at Matundasi in Chunya district. Furthermore, the Nordic Development Funds (NDF) project on the removal of barriers to introduction of cleaner artisanal gold mining and extraction technologies at Rwamagasa, Geita District in the Lake Victoria Gold Field (LVGF) is clear testimony of measures being undertaken to enhance technology transfer. This has substantially enhanced environmental protection and conservation awareness among miners and the application of appropriate technology.

6.1.11 Literature Dissemination

Most small-scale miners showed appreciation to the effort being made by the Government towards dissemination of information. For instance, the availability of booklets, handouts and brochures that provide, among other things the knowledge on environmental issues, is one step forward in enhancing environmental awareness among small-scale miners. This is part of the commitment of the government as stipulated in the Mineral Policy of 1997, which covers a range of issues include:

- Environmental awareness campaigns among SSM and other related mining players;
- Appropriate amalgamation technology to avoid mercury migration in the ecosystem;
- Forestation strategies on degraded and deforested lands by SSM;
- The use of retorts in amalgam burning to recover both gold and mercury in SSM; and

- Application of environmentally friendly technologies for sustainability of the sub-sector.

6.2 Failure of Institutional Framework

Despite efforts being undertaken by the Government to facilitate growth and sustainability of the SSM sub-sector, there are also a number of failures, which have not been effectively addressed and administered by the Government. Some of these failures are discussed in the subsequent paragraphs.

6.2.1 Poor Access to Transport

Despite the efforts being made by the Government to facilitate the ZMOs and RMOs with reliable transport; the condition of vehicles at the time of this research was not good as observed in Geita, Musoma and Songea mines offices. Most vehicles are old and could hardly manage long trips to remote areas. The problem of transport in ZMOs and RMOs can hinder smooth administration, monitoring, training and enforcement of relevant pieces of mining legislation in SSM activities. SSM activities continue without proper technical guidance from MRD resulting in poor mining and processing practices which in turn, lead to a number of environmental degradations.

6.2.2 Lack of Staff Development

There is lack of facilitation, promotion and development of professional and technical staff within the MRD particularly at the zonal level where most small-scale miners operate. The worst thing is that some offices are led by inappropriate professionals who are not legally eligible do handle some of the functions stipulated in the mining legislations.

For instance, out of 8 zones, two offices are currently being led by mining technicians; these zones include Western and Eastern zones. The rest of the manpower within these zones are not professionals (Mining Engineers, Geologist and Metallurgist). This demonstrates the lack of appropriate human resources in the department.

There are 13 RMOs offices throughout the country, out of these only 10 RMOs are led by professionals. The RMOs led by non-professionals include Tunduru, Songea and Bukoba. This represents a deficit in the administration and managerial side. The rest of the manpower in these RMOs are not professional and therefore are not legible to perform some of the professional duties as stipulated in the mining legislations.

The 7 sub-sections in the MRD at the ministry's head quarters are not well staffed with competent personnel. There is lack of adequately trained technical staff who would plan and institute appropriate training for small-scale miners and instill good mining and processing practices operated in an environmentally friendly manner for sustainability of SSM sub-sector.

These shortages indicate that MRD is currently inadequately repositioned to handle the challenges facing the mining sector particularly the SSM sub-sector, which always need technical guidance and support from Government.

6.2.3 Lack of PPE for Field Officers

There is lack of PPE among members of staff in the MRD especially in ZMOs and RMOs countrywide. The equipment includes helmets, safety boots, safety glasses, safety belts, gloves as well as safety clothes. The PPE are important for the field officers who provide extension services to small-scale miners on good mining and processing practices and working in the remote areas where environmental problems, safety and health risky are high. Field officers also

lack facilities like poisonous gas and dust detectors while inspecting mines. Field officers are supposed to be role models and need PPE while demonstrating good mining and processing practices to SSM.

6.2.4 Lack of Field Equipment for Field Officers

The ZMOs lack working field equipment such as GPS, campus, chains, topo sheets, geological maps and drawing utensils in some cases. The equipment are used to demarcate and draw the boundaries for SSM concessions particularly in illegal and mineral rushes areas. Lack of equipment means the legalization process becomes difficult because areas need to be demarcated and allocated to respective applicants. Illegal mining activities continue exacerbating the problem of environment degradation and loss of government revenue from SSM sub-sector.

6.2.5 Inadequate Operational Funds for ZMOs

There is lack of enough and timely delivered operational funds to ZMOs/RMOs from the head quarters in DSM. The operational funds are needed for:

- Preparing training materials for small-scale miners on good mining and processing practices, environment, safety, health and HIV/AIDS;
- Travelling allowances for the field officers; and
- Maintenance of field vehicles.

Lack of enough training funds has resulted in the SSM sub-sector operating without proper technical guidance and illegality. Further, inadequate operational funds hinder monitoring of illegal mining activities resulting in numerous environmental degradation and loss of Government revenue.

6.2.6 Poor Infrastructure

The poor quality of roads to reach the remotest areas where most small-scale miners operate also has adverse effects on the performance of the SSM sub-sector. Most roads are poorly done and are hardly maintained. Poor roads have made it difficult for the field officers to travel to SSM centers especially during the rainy season. Most field trips to the remotest SSM centers are only undertaken only during the dry season. SSM operations continue without proper monitoring and technical guidance and this has led to increase in illegal mining activities due to a number mineral rushes discovery. Illegal mining activities are the contributing factor to environmental degradation and loss of Government revenue from the sub-sector.

6.2.7 Lack of Environmental Control Measures

The Government has not instituted environmental control measures among small-scale miners such as pollution tax, fines and other penalties based on the polluter pays principle. Small-scale miners conduct their operations haphazardly and do not strictly consider the issue of environment as a priority in their operations resulting in numerous environmental degradations, which are detrimental to the growth of the sub-sector.

6.2.8 Lack of Financial Support

There are no visible efforts so far made by the Government to encourage the local financial institutions to support SSM by formulating affordable credit schemes for the sub-sector and adjusting start-up capital requirements. The availability of capital would promote application of appropriate technologies and improving mineral exploitation in an environmentally friendly manner for sustainability of SSM sub-sector.

6.2.9 Poor Security in Mining Centers

There are no established proper authority structures, especially miners' security units in the mining camps to maintain law and order and facilitate enforcement of health, safety and environmental regulations. This would need integral approach between the government and other mining players particularly REMAS by putting up enforcement measures for the strategies to work out.

6.2.10 Lack of Mining and Processing Equipment

There is lack of facilitation by Government on the provision of appropriate and affordable mining tools, equipment and consumables and the encouragement to manufacture the same. The application of appropriate equipment would promote good mining and processing practices thereby averting environmental degradations. As already discussed, poor application of technology is one of the major contributing factors to environmental degradation

6.2.11 Lack of Promotion of Partnerships between LSM and SSM

There is lack of promotion of partnership between SSM and large-scale investors to facilitate technology transfer and optimize mineral resources exploitation in SSM activities. LSM seem to have better environmentally sustainably technologies, but the problem between LSM and SSM is the regular conflicts, mistrust and resentment often fighting over the same mineral resource. This has made it difficult to promote the partnership that would enhance technology transfer to SSM sub-sector. The Government on the other hand side has failed to facilitate the cooperation between LSM hence SSM activities are conducted by trial and error resulting in a number of environmental degradations.

6.3 Impact of Legal and Regulatory Framework

There are a number of legislations governing the mining industry in Tanzania. These include:

- The Mineral Policy of 1997;
- The Mining Act of 1998 and amended in 2004;
- The Mining Regulations of 1999 and amended in 2004;
- The Explosives Act of 1963;
- The Explosives Regulations of 1964;
- The Environmental Management Act of 2004; and
- The Environmental Impact Assessment and Audit Regulation of 2005.

A few of these legislations deal directly with SSM operations. With regard to environmental issues in SSM operations, the Mining (Environmental Management and Protection) Regulation of 1999 amended in 2004, however, has stipulated a number of environmental standards requirements for artisanal and small-scale miners (URT, 1999). However, unlike in major LSM projects, the Environmental Management Act of 2004 does not address the problem of environmental issues in the SSM sub-sector. It has been noted that most environmental mining related legislations have focused on LSM where the environmental standards required are stricter than in SSM. The salient affirmative impacts of the Mining (Environmental Management and Protection) Regulations of 1999 amended in 2004, particularly for artisanal and small-scale miners are discussed in the subsequent paragraphs.

6.3.1 Adequacy of the Regulatory Framework

The environmental standards requirements for artisanal and small-scale miners, as stipulated in the Mining (Environmental Management and Protection)

Regulations of 1999 and amended in 2004 are adequate. These environmental standards include:

- No vegetation clearing;
- The use of retorts in gold recovery;
- Abandoned workings to be backfilled or fenced;
- Tailings disposal;
- Children not to be employed in SSM;
- Pit latrine to be constructed;
- Protected gears to be used;
- Damaged areas to be inspected;
- No cyanide leaching to be used; and
- Offences to be employed for non compliances
- Construction of settling ponds

However it was observed that, most small-scale miners do not abide to most of these environmental standards. The problem of non compliance among small-scale miners has been exacerbated by a number of factors. Some of these factors include:

- Lack of appropriate technology and environmental knowledge among small-scale miners resulting in mining and processing being done on trial and error basis resulting in numerous environmental degradations;
- Lack of monitoring and enforcement of relevant environmental legislations due to inability of the institutional framework support to handle SSM activities; and
- Lack of finance for small-scale miners to adopt good mining and processing practices.

6.3.2 Gaps in the Regulatory Framework

6.3.2.1 Waste Dumps

Waste generated in SSM centers is dumped carelessly. This is partly because the environmental standards requirements as stipulated in the Mining (Environmental Management and Protection) Regulation of 1999 and amended in 2004, do not oblige small-scale miners to have waste dumps in their mining concessions. This is also partly due to the fact that miners consider transporting waste to the waste dumps as an additional cost. This has resulted in all rubble, wastes and debris randomly dumped in the mining concession and are the major causes of environmental degradation.

6.3.2.2 Rehabilitation Programmes

The environmental standards requirements as stipulated in the Mining (Environmental Management and Protection) Regulation of 1999 and amended in 2004, do not require small-scale miners to have rehabilitation programmes in their mining concessions. The rehabilitation programmes include planting trees around and within their mining concession. These trees eventually will be useful for timber purposes and other domestic uses such as firewood, construction of shelters and dwellings, and this will substantially reduce indiscriminate destruction of indigenous forests. Forests also provide cover from soil erosion.

6.3.2.3 Management of Mineral Rushes

The study has also revealed that mineral rushes play a big role in promulgating environmental problems in SSM. The Mining Act of 1998 and amended 2004 has empowered the Minister for Energy and Minerals to deal with mineral rushes areas in consultation with the Mining Advisory Committee (MAC).This

procedure seems to be tedious and bureaucratic in turn encourages illicit mineral exploitation, illegal marketing arrangements exacerbating the problem of environmental degradation and loss of Government revenue.

The discretional powers vested in the minister by the Act ineffective to comprehensively administer the problem due to a number of other burning Governmental and political responsibilities vested in him/her. This has resulted in most earmarked mineral rushes areas remaining unattended to and become major established areas for illegal activities thus exacerbating the problem of environmental degradation and loss of Government revenues. Some of the obvious examples of the current procedure failing to deal with mineral rushes and illegal mining include:

- Illegal mining activities at Masugulu, Mkako and Mkeso in the southern zone; illegal miners have been in the area since 1992; and
- The matabe illegal mining activities in the boundaries of Geita and Biharamulo districts have been there since 1996.

CHAPTER SEVEN

ANALYSIS AND DISCUSSION OF RESULTS

7.0 Introduction

The study undertaken has established that the environmental degradation caused by the SSM sub-sector predominantly arise from poor mining and processing practices and use of inappropriate technologies. Other contributing factors include: lack of general knowledge on environment, economic limitations, inadequacy of the institutional framework and lack of enforcement of the mining legislations. The major results from the questionnaire obtained from SSM centers visited are presented graphically and in a tabular form (Appendix L), discussed and analyzed under this chapter.

7.1 Environmental Degradation

The study has established a number of environmental degradations emanating from SSM activities and are analyzed and discussed in the subsequent sections.

7.1.1 Deforestation

The dense forests that existed in gemstone mining centers at Masugulu, Mkako and Mkeso have been completely cut down by small-scale miners. Similarly, the valuable indigenous trees and colored shrubs at Mugusu, Nyarugusu and Rwamagasa gold mining centers in Geita district as well as Masasi in Mtwara region have been completely destroyed by small-scale miners to let mining and other activities progress.

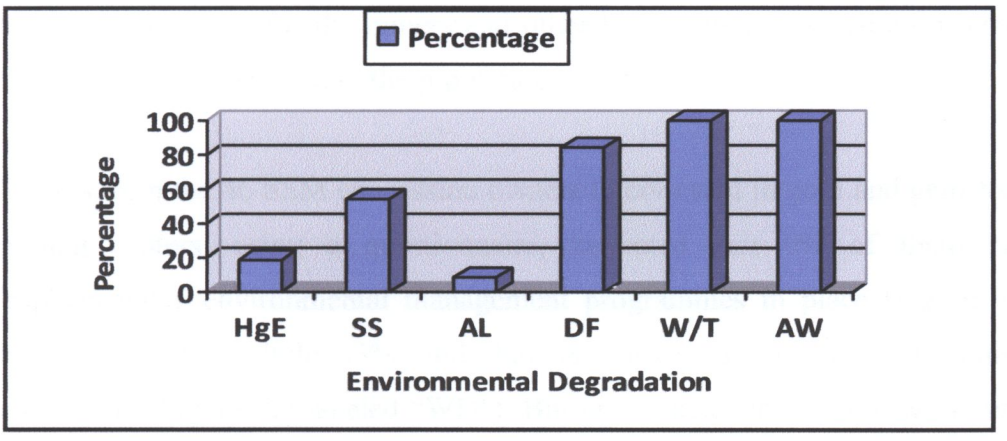


Fig 7.1: Magnitude of Environmental Degradation in SSM in Tanzania.
Key: HgE- Mercury Exposure; SS-Siltation and Sedimentation; AL-Aquatic Loss Life; DF-Deforestation; W/T-Waste and Tailing; AW-Abandoned Workings;

Results from the 46 SSM concession owners interviewed in gold and gemstone mining centers, using a questionnaire, indicates that 85% of small scale miners have been felling valuable indigenous trees to let mining progress (Figure 7.1 labeled "DF"). This suggests that the SSM sub-sector needs serious attention to rescue the situation otherwise the remaining valuable indigenous forest within and around the mining centers will be reduced to barren region.

Illegal mining activities and the several mineral rushes occurring throughout the country also contribute significantly to environmental degradation and call for stiff measures to control them including legalization

7.1.2 Land Degradation

Environmental standards require small-scale miners to backfill or fence the abandoned workings in their mining concessions. However, small-scale miners do not abide by these standards as this is considered an additional cost (Figure 7.1 labeled "AW"). The piles of waste and tailing also are dumped carelessly in the mining concessions making the arable land useless for other economic activities (Figure 7.1 labeled "W/T"). Furthermore, abandoned pits and shafts

become death traps for the miners and other land users and breeding grounds for mosquitoes exacerbating the problem of malaria.

Results from the 46 SSM concession owners interviewed in gold and gemstone mining centers, using a questionnaire, indicated that 0% of them had implementable environmental management programmes in place (Figure 7.2 labeled "EMP"). While 35% said they had waste dumps in their mining concession (Figure 7.2 labeled "WD"). But upon ocular inspection, waste was found dumped carelessly in the mining concessions hence the magnitude of 100% of not having waste dumps (Figure 7.1). Transporting waste to designated dumps is considered as an additional cost. Further, 80% sites of SSM in SSGM centers use cemented tailing dumps to control migration of mercury in the ecosystem during gold amalgamation (Figure 7.2 labeled "WP"). The awareness of using cemented tailings dumps has substantially reduced mercury migration into the ecosystem and partly has been influenced by a number of out-reaches training programmes conducted by the Government and a few NGOs. The tailings dumps however, were found to have limited carrying capacities to accommodate the large quantities of tailings produced. Because mining and processing of minerals in most SSM centers visited are done by trial and error this leads to environmental degradation.

7.1.3 Siltation, Sedimentation and Deviation of Surface Water Sources

Mining of gemstones is done within river and stream systems and on soft gravel grounds. Washing of gemstones also is done within Ngembambili River and other streams available resulting in siltation, sedimentation and river blockages to other water users living downstream. Similarly, small-scale gold miners at Rwamagasa have dugout the Isilinge riverbed and riverbank resulting in siltation and sedimentation.

Results from the 46 SSM concession owners interviewed using a questionnaire indicate that, 57% of small scale miners acknowledged to have caused siltation and sedimentation of water bodies (Figure 7.1 labeled "SS"). This proportion may seem insignificant because the questionnaire did not capture data on illegal mining activities where most of this menace exists and this is due to their legal status. This result, however, indicates that small-scale miners, if not properly handled, would cause siltation and sedimentation in all the rivers and streams in and around the mining centers and this will lead to blockages of water bodies and destruction of aquatic organisms.

Small-scale miners divert rivers and stream systems to let mining progress. Results from the 46 SSM concession owners interviewed indicate that 86% of small scale miners acknowledged to have diverted rivers and streams in gemstones mining centers alone to let mining progress.

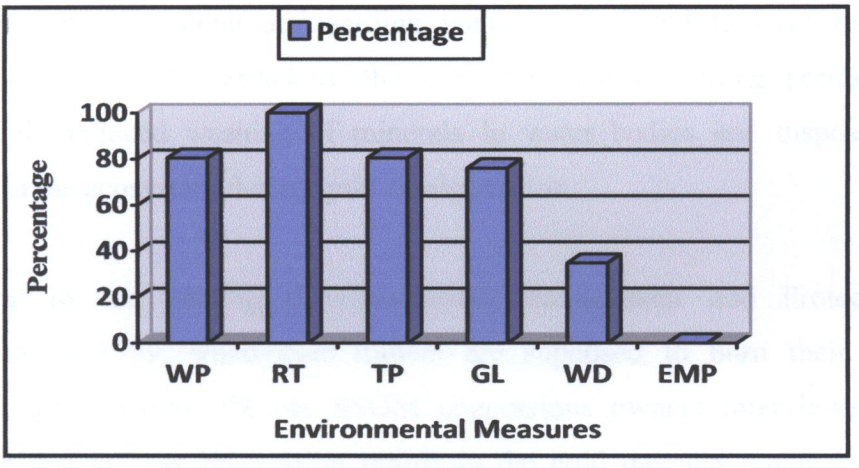


Fig 7.2: Environmental Measures Taken by Small Scale Miners.
Key: WP; Washing Pond;, RT-Retort; TP-Tailing Ponds; GL-Gloves; WD-Waste Dump; EMP-Environmental Management Programmes

7.1.4 Mercury Use in Gold Recovery

SSGM use mercury in gold recovery as observed at Mugusu, Nyarugusu and Rwamagasa mining centers in Geita district as well as at Masasi in Mtwara region. Some small-scale miners do not take safety, health and environmental

measures while handling and using mercury and are exposed to poisonous mercury.

Results from the 32 SSM concession owners interviewed using a questionnaire indicate that 19% of small-scale miners acknowledged to have been exposed to Mercury during gold amalgamation phase (Figure 7.1 labeled "HgE"). The figure seems insignificant because, in the recent past, there has been a number of outreach training and sensitization programmes by the Government and a few NGOs on how mercury can be appropriately handled in gold recovery.

Despite the use of washing and cemented settling ponds being an obligation for small-scale miners, gemstone miners do not abide to this requirement and consider it as an additional cost in their operations. 80% of the SSGM concession owners interviewed indicated that they had washing and cemented settling ponds in gold mining centers (Figure 7.2 labeled "TP"). However, on ocular inspection washing and settling ponds were found to have limited carrying capacities. Nevertheless, the use of cemented settling ponds has significantly reduced washing of minerals in water bodies and disposal of mercury in the ecosystem during gold amalgamation.

According to the Mining (Environmental Management and Protection) Regulation of 1999, small-scale miners are supposed to burn their gold amalgam using retorts. Of the SSGM concessions owners interviewed all acknowledged to have been using retorts in the gold mercury amalgamation process. This has partly been influenced by a number of outreach training and awareness programmes conducted by the Government and a few NGOs on how mercury can be appropriately handled and used in gold recovery.

Despite the fact that protective gear is an obligation for artisanal and small-scale miners, some small-scale miners were found not abide by this requirement. Results from the 32 SSGM concessions owners interviewed

indicate that 76% of the small-scale miners acknowledged using gloves in gold amalgamation (Figure 7.2 labeled "GL"). This result is significant due to the fact that working conditions in gold mining centers are strict because of the use of poisonous mercury in gold recovery. However, Illegal miners were seen amalgamating gold with their bare hands and burn the amalgam in open air subsequently releasing a lot of mercury vapour into the ecosystem. This exposes the miners to the poisonous mercury.

7.2 Impact of the Institutional Framework

The adequacy and gaps of the institutional framework in the administration of the SSM sub-sector are analyzed and in the following sections.

7.2.1 Adequacy of Institutional Framework Support

The MRD has made and is making a number of efforts in ensuring the effective growth and development of environmentally sustainable SSM sub-sector. Some of the major measures being undertaken by the Government include:

- The Government has been restructuring the MRD institutional framework to properly and effectively administer, promote and service the mineral sector particularly the SSM sub-sector.
- The establishment of the environmental sub-section (HEM) within the MRD is a clear testimony of Government's commitment to the growth of environmentally sustainable SSM sub-sector in the country. The HEM is responsible, among other things, for overseeing all environmental issues in the mining industry particularly those related to the SSM sub-sector and take appropriate measures to mitigate environmental degradation;
- The establishment of the coordination and extension services sub-section (HCES) in MRD has facilitated coordination of the ZMOs countrywide. Furthermore, the sub-section is responsible, among other things, for

coordinating training arrangements and extension services for small-scale miners in collaboration with the ZMOs. Training on good mining and processing practices enhance environmental protection, mineral exploitation and collection of Government revenue;

- Establishment of the mines inspectorate sub-section led by the Chief Inspector of Mines (CIM) has facilitated, among other things for, inspection, monitoring and instituting legal action for non-compliance. This has helped in behavior change among small scale miners and substantially reduced environmental degradation in the SSM sub-sector;
- The establishment of 8 ZMOs and 13 RMOs throughout the country is a clear indication of the commitment of Government to the development of SSM sub-sector. This has brought the needful services closer to small-scale miners who always need technical support from the government. The ZMOs/RMOs are responsible, among other things, for coordinating and provision of training good mining and processing practices, environment, safety and health issues;
- The establishment of a computerized Mining Cadastre Information Management System (MCIMS) within MRD has facilitated the licensing procedure particularly for small-scale miners being more open and realistic. The system has made it possible to trace and legalize illegal miners who are the major source of environmental degradations in SSM.
- The MEM initiated radio and television programmes in order, among other things, to sensitize small-scale miners and other stake holders on environmental issues including conservation, management and protection;
- The Government has strengthened the Madini Mining Training Institute in Dodoma. Currently the institution is offering diplomas in geology, mining, metallurgy and environment as well as short courses for small-scale miners. The DSM Institute of Technology (DIT) also has instituted diploma in mining related fields. Furthermore, the Government has established Department of Mining Engineering at the University of DSM (UDSM). These are clear indications of the commitment of the Government to the

development of the mining industry as the whole and small scale mining in particular.

- The Government has undertaken a number of projects to facilitate technology transfer to small-scale miners. For instance, an extraction technology demonstration plant was established at Matundasi in Chunya district. Furthermore, a project was introduced for the removal of barriers to introduction of cleaner artisanal gold mining and extraction technology at Rwamagasa, in Geita District in the LVGF. This has substantially improved the handling of mercury in gold recovery among small scale gold miners.

7.2.2 Failure of the Institutional Framework

The problem of inadequate budgetary allocation to the responsible Ministry has resulted in a number of institutional failures to carry out its mandate. For instance, the Government has not been able to adequately provide reliable transport to enable ZMOs and RMOs travel to the mining centers to provide extension services, and enforce mining regulations. This has led to a largely unsupervised sector.

Institutional failure is also exemplified by the lack of human resource development of technical staff particularly at the zonal level. Some ZMOs and RMOs offices are led by mining technicians who lack appropriate training to undertake the institution's assignments. Qualified technical staffs are essential to provide technical training to small-scale miners on good mining and processing practices and, preservation of environment.

Other operational inadequacies include the lack of field equipment for ZMOs/RMOs such as GPS, campus, chains, map sheets, geological maps and drawing tools. The equipment is essential to facilitate among other things for, demarcating boundaries in mineral rushes and illegal mining areas to facilitate

legalization. Lack of field equipment means illegal mining activities continue unabated thereby exacerbating the problem environmental degradation and loss Government revenues.

There is lack of personal protective equipment (PPE) among field officers at the zonal level. Field officers are a role model and need PPE while demonstrating good mining and processing practices, monitoring, inspecting unsafe areas and enforcing relevant mining and environmental legislations. This instills practical sense of responsibility among small-scale miners.

The lack of good infrastructure e.g. roads and communication etc to reach the remotest areas where most small-scale miners operate is also a setback towards the development of SSM sub-sector. This means that field officers are unable to reach the mining centers during the rainy season. This has led to uncontrolled illegal mining activities. Illegal mining activities employ poor mining and processing practices and poor market arrangements resulting in environmental degradation and loss of Government revenue.

The Government has not instituted environmental control measures such as pollution tax fines and other penalties based on the principle of polluter pays. This has led to SSM activities being conducted haphazardly in a way the issue of environment is not considered as a priority among small scale miners resulting in a number of environmental degradation.

The Government has not made any tangible efforts to encourage local financial institutions to support small-scale miners by formulating affordable credit schemes for the sub-sector. This is because there is a negative attitude given to the sub-sector by most financial institutions as this is one of the high risk investment. Affordable capital would work as a major tool in promoting appropriate technologies and improving mineral exploitation in SSM activities averting the environmental degradations and increase Government revenues.

The Government has not been able to establish proper authority structures especially miners' security units in the mining camps to administer law and order and facilitate enforcement of health, safety and environmental regulations. This needs a collaboration approach between the Government and other players in the field particularly REMAS by putting up enforcement measures for the strategy to work out. This has been aggravated by the failures of most REMAs and hence the failure of the collaboration.

The government has not facilitated the availability of appropriate and affordable mining tools, equipment and consumables and encouraging the manufacture and supply of the same. This has been a result of poor promotion of local manufacturer of mining equipment. The application of appropriate equipment would promote good mining and processing practices conducted in an environmentally friendly manner for sustainability of the sub-sector. As already has been revealed, poor application of technology is one of the major contributing factors to environmental degradation in SSM sub-sector.

The Government has not promoted the partnership between small-scale miners and large-scale investors to facilitate technology transfer to and optimization of mineral resources exploitation by small-scale miners. LSM have better technologies and are conducted in an environmentally friendly manner. The problem between LSM and SSM is the regular conflict, mistrust and resentment in that the two groups are often fighting over the same mineral resource. This has made it difficult to promote the partnership that would enhance technology transfer to small-scale miners. The government on the other side had failed also to facilitate this cooperation hence SSM activities are conducted by trial and error resulting in a number of environmental degradations.

7.3 Impact of Legal and Regulatory Framework

The adequacy and gaps of the regulatory framework structure will be discussed and analyzed in the subsequent sections.

7.3.1 Adequacy of the Regulatory Framework

The environmental requirement standards for artisanal and small-scale miners though adequate are not fully adhered to by small-scale miners largely due to the nature of their operations.

However, some do follow the standards by setting up washing and settling ponds in their mining concessions. Currently, small-scale gold miners process their gold in a closed circuit (crushing, grinding, sluicing, washing and gold-mercury amalgamation) as observed at Nyarugusu, Mugusu and Rwamagasa mining centers. This can be demonstrated by results from 46 SSM concession owners interviewed during the survey. The result indicated that 80% of these small scale miners had washing and settling ponds in their mining concessions. Most of these washing and settling ponds were seen in gold mining centers but mostly with limited carrying capacities to accommodate large quantities of tailings produced. However, it was observed that gemstone miners do not have washing and settling ponds in their mining concessions.

Mercury-contaminated tailings and washing waters are stored in cemented constructed settling ponds to control migration into the rest of the environment. Containment is an effective measure to control the migration of mercury into the ecosystem as well as control of siltation of water bodies.

Gold is recovered by burning the amalgam using a retort and mercury is recovered and reused. It was observed from the results of the survey that all small-scale gold miners use retorts for gold recovery. However, there is still a

rampant use of mercury in illegal gold mining activities and this needs special attention of the mining authorities to legalize them.

The government has streamlined the licensing procedures to harmonize SSM and LSM operations ensuring transparency and fairness by conferring ownership of mineral rights on the basis of first come, first served basis. The transparence and fairness basis system has influenced many illegal miners to legalize their activities thereby promoting good mining and processing practices which enhance environmental protection.

7.3.2 Gaps in the Regulatory Framework

The environmental standards requirements do not oblige artisanal and small-scale miners to have waste dumping areas in their mining concessions. It is therefore not surprising that gold and gemstone SSM centers visited do not have planned waste dumps. These consider transporting waste to the dumping areas as an extra cost. This means that mine waste is carelessly dumped. This is one of observed weakness that needs special attention.

The environmental standards requirement for artisanal and small-scale miners as stipulated in the Mining (Environmental Management and Protection) Regulation of 1999 and amended in 2004 do not require small-scale miners to conduct rehabilitation programmes in their mining concessions. This is a major weakness observed in the Mining Regulation of 1999 amended in 2004.

The current procedure of dealing with mineral rushes seems to be tedious and bureaucratic and as such has encouraged illicit mineral exploitation, poor marketing arrangements, which have aggravated environmental degradation and loss of government revenue. The discretional powers vested in the Minister for Energy and Minerals by the Mining Act of 1998 and amended in 2004 are not effective in dealing with mineral rushes as observed in the continued existence

of illegal mining activities in Masugulu, Mkako and Mkeso (southern zone), which have been there since 1992 and in Matabe and Biharamulo districts since 1996.

7.4 Lack of Financial Resources

Despite its positive contribution to the national economy, the SSM sub-sector still faces financial constraints. In most cases financial institutions are reluctant to support SSM activities mainly due to the perceived high risks of investment in the sub-sector.

These institutions also require unbearable collateral. Consequently, small-scale miners are unable to access funds for implementing good mining and processing practices that may enhance effective environmental management.

CHAPTER EIGHT

CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The study has established that there are many factors contributing to environmental degradation in SSM sub-sector in Tanzania. The major ones identified include:

- The poor application and lack of access to appropriate technology;
- Inadequate institutional framework support to effectively manage the sub-sector;
- Lack of enforcement of relevant environmental & mining legislations;
- Poor funding to the support ministry.

The legal and regulatory framework structure in relation to environmental management and protection in the SSM sub-sector is partly inadequate. A serious lacuna is observed in the Mining (Environmental Management and Protection) Regulations of 1999 and amended in 2004, which do not require small-scale miners to conduct rehabilitation programmes (demarcating areas for planting trees and waste dumps) in their mining concessions.

Some of the environmental degradations established by this study are serious such as abandoned pits, shafts, deforestation, siltation and sedimentation and deviation of sources of surface water. Further, piles of waste, debris, rubble and tailing from mining and processing practices have resulted in arable land becoming useless for other economic activities such as farming and livestock

The problem of rampant use of mercury without following environmental standards requirement for SSM as stipulated in the Mining Regulations of 1999

and amended in 2004 is widely spread in illegal gold mining centers as observed at Buhemba in Musoma rural district;

There is a need to promote a better understanding of the environmental impacts of SSM activities among small-scale miners. Most small-scale miners have limited knowledge on issues such as deforestation, chemical contamination of water bodies and other surroundings, siltation and sedimentation, deviation and blockages of water bodies and general land degradation.

8.2 Recommendations

From the conclusions made above, the following recommendations can be drawn.

i. The Government needs to formulate an appropriate mineral policy coupled with effective legal and regulatory mechanisms focused on health, safety and environment for the sub-sector to be environmentally sustainable.

ii. The Mining (Environmental Management and Protection) Regulations of 1999 should oblige small-scale miners to demarcate part of their mining concessions to designate some areas to re-vegetation and waste dumping areas as part of the environmental management programmes.

iii. The discretional powers vested in the Minister for Energy and Minerals by the Mining Act of 1998 and amended in 2004, to deal with mineral rushes are not effective because of the bureaucracy involved. For the effective management of mineral rushes, it is recommended that such powers be vested in the Commissioner for Minerals (CM) and further delegated to ZMOs who will be responsible, among other things for, demarcating mineral rushes areas and advise CM to issue primary mining licences (PML). The mode of demarcation and allocation would be as stipulated in sections 14 and 70 of the Mining Act of 1998 amended in 2004, respectively. The role of MAC in this context is insignificant because, the

problem of illegal mining is more of a technical one than it is being treated and should entirely be the responsibility of CM. Mineral rushes are associated with illegal mining activities. Being uncontrolled, it contributes to environmental degradation and loss of Government revenue.

iv. The Government should rationalize the informal mining sector so that it begins to make a significant contribution to the national economy. The Government should also ensure there are sufficient fiscal incentives for miners to formalize their activities. The incentives could include, for instance, the existing annual presidential environmental award, establishing an appropriate, attractive and easily adoptable taxation regime for them to remain in formal operations. In order to attain this, the Government should work with the local financial institutions so that their policies mesh with small-scale miners' requirements to facilitate soft loans and utilize the same as capital in their mining investments. Furthermore, the government should collaborate with companies advanced in mining and processing technologies so that such companies can provide SSM sub-sector with equipment on loan basis so that they exploit mineral deposits in an environmentally friendly manner consequently improve government revenues collection for sustainability of the sub-sector.

v. The MRD institutional framework and other supporting institutions need to be strengthened with appropriately trained human resources so that the role of the Government as the regulator, facilitator and services provider would be appreciated by the players in the mining sector. To ensure coherent administration of the SSM sub-sector, the Government should ensure that all the ministries involved (finance, mining and environment and local authorities) coordinate their policies for a harmonized administration of the sub-sector. Furthermore, the Government should decentralize as many MRD functions as possible to ZMOs and ensure that such functions are in line with strategies in other departments for promoting rural development as a tool for poverty alleviation.

vi. The capacity of the MRD and its sub-sections at the ministry's head quarters needs to be strengthened. The establishment of the environmental sub-section, mines inspectorate sub-section and coordination and extension services sub-section in MRD is important. These sub-sections, however, are understaffed and hardly manage the environmental challenges and responsibilities in respect of inspection, monitoring and enforcement of relevant environmental legislations. Challenges can be overcome by manning the sub-sections with adequate and trained human resources (mining engineers, geologists, metallurgists, gemologists, mineral economists and environmentalists to mention). The Government should also institute specifically a Small-Scale Mining section, which should be responsible for, among other things, for policy formulation, implementation and administration of the SSM sub-sector.

vii. The Government should strengthen the capacity of ZMOs/RMOs to monitor and institute legal actions against small-scale miners found not complying with regulations and standards. The proposed structure in Figure 8 is highly recommended for effective administration of the sub-sector at the zonal level.

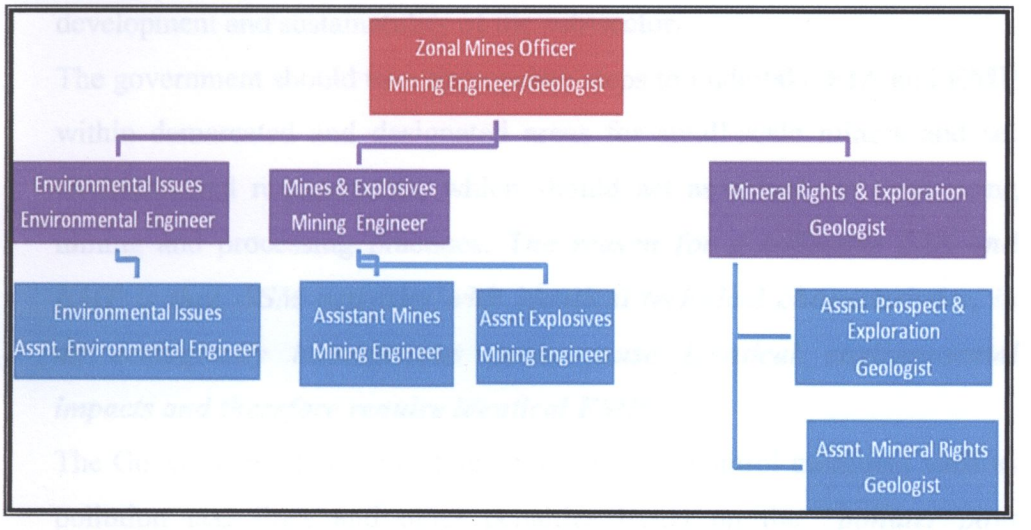


Fig 8.0: Proposed Framework for ZMOs

The structure will also cater for, among other things for, demarcating mineral rushes areas and allocating the same to applicants, carrying out collective EIA and EMP in designated SSM concessions and institute specific environmental requirements within the designated areas. The structure will also cater for monitoring of illegal mining as a tool to enhance environmental protection. Further, the implementation of the proposed structure of MRD (Appendix G) should be considered as a vital for effective management of the mineral sector as the whole particularly at the ZMOs and RMOs.

viii. The ZMOs need to be fully funded so that they can reach all mining centers throughout the year for effective administration of the SSM sub-sector. This will enable the field officers to plan and execute training arrangements on environment, safety, health, demonstrate good mining and processing practices, monitoring and institute legal action for non-compliance. Field officers will also facilitate management of illegal mining and mineral rushes, which are the main contributing factors to environmental degradation and loss of government revenue. Furthermore, the Government should improve the remuneration and other working conditions for MRD field officers to boost their working morally for development and sustainability of the sub-sector.

ix. The government should take appropriate steps to undertake **EIA** and **EMP** within demarcated and designated areas for small-scale miners and set environmental requirements, which should act as a tool for monitoring mining and processing practices. ***The reason for a collective EIA and EMP is that, SSM activities with identical technical characteristics, in an ecologically homogenous zone, cause identical environmental impacts and therefore require identical EMP.***

x. The Government should institute environmental control measures such as pollution tax, fines and other penalties based on the *"polluter pays principle"*. This would instill a sense of responsibility among small-scale miners by prioritizing environment issues whilst executing relevant

operations. This needs to be worked out in collaboration with REMAS by establishing proper authority structures especially miners' security units in the mining camps to uphold law and order and facilitate enforcement of health, safety and environmental regulations. Furthermore, the Government should endeavor to strengthen the miners' associations (REMAS, FEMATA and TAWOMA), which could be partners in promoting the implementation of environmental standards in the sector.

xi. The inaccessibility and poor application of appropriate mining and processing technologies are some of the major factors contributing to environmental degradation. To ensure substantial reduction in environmental degradation in the sub-sector, the technology employed must be technically efficient, low in investment and operating costs and should meet the environmental standards set for the SSM sub-sector. ***To attain this, the technology should abide to the principle of "A win-win-option" or "win do not lose" that should be the only criteria i.e. environmental improvements and economic advantages should be an integrated solution, no "end-of-pipe".***

xii. The SSM sub-sector tends to demand better access to financing. But in practice, access to credits and formal banking to ensure access to appropriate technology is difficult because of the peculiarities in the sub-sector with its inherent high investment risks where low utility expectations do not outweigh the risks. The financing institutions consider the sector as of high risk and deny negotiation with clients lacking bankable guarantees. Consequently, small-scale miners are unable to access the funds for implementing good mining and processing practices that result in sound environmental management. It is recommended therefore that, the financing of the SSM projects should be tailor-made instead of regular bank credits. Consideration should be made to such financing models as own capital resources by slow building, joint ventures and equity.

xiii. Finally, to ensure a stable, smooth and sustainable SSM sub-sector, the Government should embark on promoting partnership between SSM and LSM to facilitate technology transfer, which optimizes mineral resources exploitation in an effective and in an environment friendly manner.

APPENDIX A

Table 1: LSM and SSM Mineral Rights Issued 1999-2006

Type of the License	Number of Licences
Prospecting Licence	3,840
Mining (SML, ML, GML)	271
Reconnaissance Licence	479
Total LSM	4,590
Primary Mining Licences	6,537

Source: Ministry of Energy and Minerals, HQ, DSM, February 2007

APPENDIX B

Table 2: Contribution of LSGM in the Nation Economy 1999-2004

		1999	2000	2001	2002	2003	2004
Mineral Production (in US $ million)		30.70	143.40	308.20	387.20	515.10	652.35
Taxes to Government (in US $ million)		4.90	18.90	24.40	34.20	42.30	48.50
Community Projects (in US $ million)		4.20	8.00	3.60	1.50	1.00	4.60
Training of Workers (in US $ million)		0.04	2.10	2.40	2.40	2.40	3.00
Procurement of goods and services (in US $ million)	**Local**	36.10	104.70	109.50	125.40	146.20	133.50
	Foreign	17.10	73.50	75.50	111.90	127.50	126.70
Catering services by local companies (in US $ million)		1.20	3.50	7.40	6.00	2.30	4.60
Employment (number)	**Foreign workers**	47	238	267	316	381	387
	Tanzanian workers	1524	3034	3932	5260	6324	8346

Source: Ministry of Energy and Minerals, Tanzania Chamber of Mines and LSGM Producers.

APPENDIX C

Table 3: Fiscal Incentives for the Mining Sector

Item	Incentives (%)
Corporate tax	30
Royalty payable	3 and 5
Capital goods for exploration and mining development	0
Sales tax on capital goods	0
Capital allowance in deductions in years of income	0
Withholding tax on dividends	0
Withholding tax on interest	0

Source: Ministry of Industry, Financial law (Miscellaneous Amendment) Act 1997

APPENDIX D

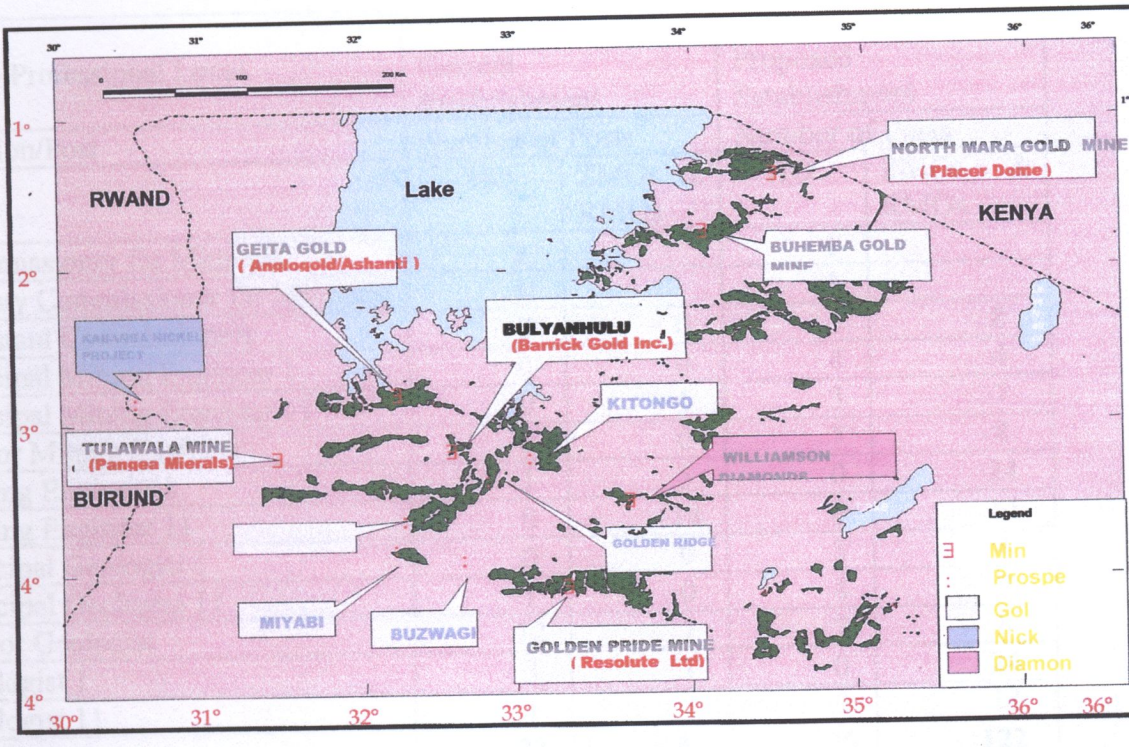
Table 4: Gold Production Capacities in LSGM 1998-2005

Name of a Mine	Owner	Ounces/year
Golden Pride, Nzega (1998)	Resolute Tanzania Limited (RTL)	200,000
Geita Gold Mine (2000)	Ashanti Goldfields & Anglo-Gold	650,000
Bulyanhulu Gold Mine (2001)	Barrick Gold Tanzania Ltd	450,000
North Mara Gold Mine (2002)	Barrick Gold Tanzania Ltd	220,000
Buhemba Gold Mine (2003)	Meremeta Limited	80,000
Tulawaka Gold Mine (2005)	Barrick Gold Tanzania &Pangea	100,000
Total		**1,620,000**

Source: Ministry of Energy and Minerals, HQ, DSM, February 2007

APPENDIX E

Figure E: Large Scale Mines and Prospects in the LVGF



Source: Ministry of Energy and Minerals, HQ, DSM, February 2007

APPENDIX F

Table 5: Categorization of Mineral Rights under the Mining Act of 1998

Category	Type of Licence	Duration (years)	Renewal (years)
LSM	Prospecting Licence with initial Reconnaissance	2	Non renewal
	Prospecting Licence	3	2 twice
	Special Mining Licence	25	<25
	Mining Licence	10	10
	Gemstone Mining Licence	10	10
SSM	Primary Prospecting Licence	1	1
	Primary Mining License	5	5

Source: Mining Act and its Regulations of 1998 and 1999 Respectively

APPENDIX G

Table G: Current and Proposed Technical Manpower in MRD

MRD Professional Level	Current Establishment		Proposed Establishment	
Position/Post	Number of Posts		Number of Posts	
	HQ	ZMOs & RMOs	HQ	ZMOs & RMOs
Commissioner for Minerals	1		1	
Deputy Commissioner for Minerals	1		1	
Assistant Commissioners	2	0	5	8
Principal Mining Engineer 1	0	0	4	4
Principal Mining Engineer 11	0	1	3	7
Senior Mining Engineer	0	0	7	8
Mining Engineer 1	1	5	0	24
Mining Engineer 11	0	14	0	14
Principal Geologist 1	0	0	3	4
Principal Geologist 11	1	0	4	7
Senior Geologist	12	7	7	8
Geologist 1	3	1	0	24
Geologist 11	1	4	0	14
Total	**22**	**32**	**35**	**122**

Source: Ministry of Energy and Minerals, HQ, DSM Feb 2007

APPENDIX I

QUESTIONNAIRE FOR MINISTRY OF ENERGY AND MINERALS OFFICIALS

- Department
- Age
- Professional
- Length of service in the department.

1. What services do you provide to SSM in ensuring sustainability of SSM operation?

.....

.....

2. What are your views on adequacy of the Mining (environmental) regulations for SSM? Explain briefly

.....

.....

3. Are there any environmental degradation observed in your areas caused by SSM sub-sector? Mention a few if there are any.

4. Is there a need for SSM to submit EIA and EMP upon applying for a mineral right under division IV? Yes/No

5. If the answer in 4 is yes, explain briefly

.....

.....

If the answer in 4 is no, what should be done then to rescue the environment?

.....

.....

6. What are the sources of such environmental degradations?

.....

.....

7. What type of licenses do you issue to SSM? (Statistical licenses for the past 10 years) (PML, PPL)

8. What type of licenses do you issue to LSM (Statistical licence for the past 10 years?) (PL, PLR, ML, SML etc.)

9. How many SSM (PML holders) are currently operating in the country?

10. What is the average statistical production per year from SSM in the past 10 years? (Gold, Gemstones, Building minerals, Salt, Diamond and Tanzanite)

11. What is the average statistics production per year from LSM in the past 10 years? (Gold, Gemstones, Building minerals, Salt, Diamond and Tanzanite)

12. What is the average exports earning from SSM? How much % is that from all the mineral exports in this country (Statistical data for the past 10 years?)

13. What is the average contribution of SSM to the GDP of this country as compared to other LSM?

14. What is the average contribution of SSM to the GDP of this country as compared to other economic activities?

15. What is the average contribution of LSM to the GDP of this country?

16. Is there a need to review the Mining (Environmental protection) regulations 1999 regarding small scale mining industry in Tanzania?

17. What is the level of manning in the department at the moment?

18. If the answer in 17 is no, then what is the level of manning required to institute the mineral department?

19. Is there enough trained manpower to institute the Mining Act 1998 and its Mining regulation of 1999 putting into consideration that the government is the regulator, monitor and facilitator? Give details

APPENDIX J

QUESTIONNAIRE FOR SMALL-SCALE MINERS

1.0 General Particulars

Name of licence holder.....

Sex.....

Total number of licences.....

Number of a licence.....

Date issued.....

Duration of the licence.....

Expiring date .....

Type of minerals mined.....

Name of the mine.....

Number of permanent workers in the mine.....

Do you have any training in SSM? Yes/No

If the answer above is yes, which fields on SSM were you trained?

.....

.....

If the answer is no, what kind of training do you desire? Explain briefly

.....

2.0 Mining Sequence

1. Explain briefly, what type of mining is in practice

.....

.....

2. Is there any mining plan in place that shows the sequence of mining operations? Yes/no

3. If the answer in 2 is yes, explain briefly how it is being implemented

.....

.....

If the answer in 2 is no, explain briefly how is mining operation conducted

.....

.....

4. Is there any environmental management plan set out in your mine for the purpose of safe guarding the environment as the result of mining and processing technique of minerals? Explain briefly?

.....

.....

5. Have you ever chopped trees, in order to let mining progress? Yes/No

6. If the answer above is yes, explain briefly the types of trees destructed?

.....

.....

7. What was the purpose of chopping the trees?

.....

8. Have you ever deviated sources of water such as rivers in order to let mining progress? Yes/No

9. If the answer above is yes, explain briefly

.....

.....

10. What type of a host (Competence) rock that is being mined?

.....

.....

11. What types of Mining equipment is in use?

.....

.....

12. Do you use any explosives in your mine? Yes/No

13. If the answer above is yes, what type(s)? Explain briefly

.....

.....

14. What are the health and environmental side effects of using explosives in mining activity? Explain briefly

.....

.....

15. Could you have conducted mining without using any explosives? Explain briefly

.....

.....

3.0 Ore and Waste Management

1. Explain briefly how is hauling system being undertaken in your mine?

.....

.....

2. Explain briefly, how do you manage waste in your mine?

.....

.....

3. Explain briefly how are tailings managed in your processing plant?

.....

.....

4.0 Mineral Processing Phases

1. Explain briefly; how you process your minerals

.....

.....

2. What type of crushing equipment do you use in your mine? Explain briefly

.....

.....

3. What type of grinding equipment do you use? Explain briefly.

.....

.....

4. Explain briefly what is the next step to be done after the grinding process? How is it done?

.....

.....

5. Is there any source of water within or nearby area which is being used by your mine in domestic and mine use? Mention the name of source of water i.e. River, Lake, Bore hole and others

.....

.....

6. Is there any demarcated or constructed washing ponds area within your licence for processing purposes? Yes/No explain briefly

.....

.....

7. If the answer is no, where do you process your minerals (gold, gemstone)?

.....

.....

8. Is there any source of water pollution in your mine? Explain briefly.

.....

.....

9. If the answer in 8 is yes to what extend? Explain briefly

.....

.....

10. What is gold amalgamation? How is it done?

.....

.....

11. Where is the source of your mercury supply in your mine? Explain briefly

.....

.....

12. What is the average ratio of mercury gold amalgamation is being used in your mine in order to get gold amalgam? Explain briefly

.....

.....

13. How is gold recovered from mercury gold amalgam?

14. Do you know that mercury is health hazardous to human and the environment?

Explain briefly.

.....

.....

15. What are you doing to protect mine workers from mercury intoxication? Any use of protective gears?

.....

.....

16. What are the side effects of mercury intoxications to the environment? Mention a few.

.....

.....

17. What is the retort? Explain briefly

.....

.....

18. What is it for?

.....

19. Have you ever used it? Yes/No

20. If the answer in 19 is yes, what are the advantages of using a retort in gold recovery?

.....

.....

21. What are the disadvantages of using a retort in gold recovery?

.....

.....

22. Are there any other methods you know which can be used in gold recovery?

.....

.....

23. Explain briefly how the tailings are managed in your processing plant

.....

.....

24. What problems do you face in Prospecting, mining and mineral processing?

.....

.....

5. Environmental Problems in SSM Centers Visited

	Mine area.....	
	Frequency	Percentage
1. Have you heard of any people getting sick due to mercury exposures in your area? Yes No No response Total respondents		
2. Have you been exposed to mercury during the course of your mining activity Yes No No response Total respondents		
3. Is your mine area close to the water body? Yes No No response Total respondents		
4. Have you noticed significant siltation and sedimentation in the water body since mining started? Yes No No response Total respondents		

5. Have you noticed significant fishery loss in the water body since mining started? Yes No No response Total respondents		
6. Do you require gloves in handling of mercury? Yes No No response Total respondents		
7. Is there a tailings pond in your processing area? Yes No No response Total respondents		
8. Is blow torching done indoors or outdoors?		
9. Are retorts used in blowtorching of the amalgam? Yes No No response Total respondents		

APPENDIX K

Table H: Definition of Small-scale Mining in Other Countries

Source	Definition of Small-scale mining (SSM)
Brazil	Individual or collective extractive work, using rudimentary tools, manual devices or simple portable machinery's - for immediate exploitation of a mineral which, by its nature, dimension, location and economic use, can be worked independent of previous exploration work, according to criteria set by the National Department of Mineral Production. **Artisanal mining "garimpagem"**: As individual work performed by panners with rudimentary forms of mining using manual or portable equipment, and applied only to alluvial, colluvial and eluvial deposits.
Burkina-Faso	Artisanal exploitation refers to activities conducted on ore bodies or deposits by natural or legal persons using traditional techniques or low mechanization levels.
Chile	Small-scale mining is defined as that mining sector that produces up to 2,000 tonnes per year of fine copper or equivalent. **Artisanal mining:** Mining operations by a person who works a mine property or process plant by himself and with or without family support, maximum number of five salaried workers, or by legal society with no more than six partners. It also includes operations by mining cooperatives with partners who are actual Artisanal miners.
Ethiopia	SSM means mining operations to be designated as such by the Minister, of which the annual run-of-mine ore does not exceed a certain limit, which differs from one mineral product to another and on the nature of mineral occurrence. **Artisanal mining:** Refers to non-mechanised mining operations of gold, platinum, precious minerals, metals, salt, clay and other similar minerals,

	by essentially manual methods carried out by individuals or groups of persons.
Ghana	SSM refers to operations of individual Ghanaians or organized groups of Ghanaians (four to eight individuals), or cooperatives of ten or more individuals, which are entirely financed by Ghanaian resources at a certain limit, and carried out on a full-time basis using simple equipment and tools. It also refers to prospecting and mining in an area designated for SSM, which uses specialized technologies & methods not involving substantial expenditure.
Tanzania	SSM is interpreted as mining conducted by Tanzanian's mineral right owners with Primary Mining License (PML), issued under division D of the Mining Act of 1998 and amended in 2004.
Guinea	SSM is the exploitation of precious minerals such as gold, diamonds and other gemstones found in primary or alluvial deposits, outcrops or sub-outcrops.
Mexico	Small-scale mines are those whose annual production values do not exceed US $ million, provided that their daily production capacity is less than 200 tonnes per day, for metal mines, and 300 tonnes per day for non-metal mines.
Philippines	SSM refers to activities which rely heavily on manual labour using simple implements and methods & do not use explosives or heavy mining equipment. Also defined as a single unit of operation involving an annual production of not exceeding 50,000 tonnes of run-of-mine ore with the following requisites: • Working is Artisanal, either open-cast or shallow underground mining without the use of sophisticated mining equipment. • Minimal investment on infrastructures and processing plants (not

	exceeding 10 million pesos). • Heavy reliance on manual labour (ratio of labour cost to equipment utilization cost to produce, process and market one tonne of ore is equivalent to, or exceeding one).
Suriname	SSM is the exploitation of mineral deposits, which due to their mode of occurrence and their size, can be mined economically by simple techniques.
United Nations	1972 - SSM is any single unit mining operation having an annual production of materials of 50,000 tonnes, or less as measured at the entrance of the mine.
ITDG	**Intermediate Technology Development Group** Small-scale miners are "poor people; individuals or small groups who are dependent upon mining for a living; who use rudimentary tools and techniques (e.g. picks, chisels, sluices and pans) to exploit their mineral deposits".

Source: Mining Minerals and Sustainable Development MMSD (UNEP), 2002.

Appendix L

Summarized Results from the Questionnaire in SSM Centers Visited

Key Marks:

A	B	C	D	E	F	G
Mugusu	Nyarugusu	Rwamagasa	Ngembambili	Masugulu	Mkako	Frequency

Question Asked	A	B	C	D	E	F	T
	G	G	G	G	G	G	G
Have you heard of people getting sick due to mercury exposure in your mine?							
Yes		1					**1**
No	3	15	8				**26**
No response	1	2	2				**5**
Total Respondents	**4**	**18**	**10**				**32**
Have you been exposed to mercury in the course of gold amalgamation?							
Yes	1	3	2				**6**
No	3	15	8				**26**
No response							
Total Respondents	**4**	**18**	**10**				**32**
Is your mining area close to a water body?							
Yes	4	6	6	6	4		**26**
No		12	4	4			**20**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Have you noticed siltation and sedimentation since mining started?							
Yes	4	6	5	6	4		**25**
No		12	5	4			**21**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Have you noticed significant fish loss in the water body since mining started?							
Yes				4			**4**
No	4	18	10	6	4		**42**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**

Is there any environmental management plan in your mine for safe guarding the environment?							
Yes							
No	4	18	10	10	4		**46**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Have you ever chopped trees, in order to let mining progress?							
Yes	3	15	7	10	4		**39**
No		3	3				**6**
No response	1						**1**
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Have you ever deviated sources of water such as a river in order to let mining progress?							
Yes			1	10	4		**15**
No	4	18	9				**31**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Do you use explosives in your mine?							
Yes	4	12	5				**21**
No		6	5	10	4		**25**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Could you have conducted mining without using any explosives?							
Yes		6	5	10	4		**25**
No	4	12	5				**21**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Is there any demarcated or constructed washing ponds within your licences for processing purposes							
Yes	4	18	10	4	1		**37**
No				6	3		**9**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Have you ever used a retort?							
Yes	4	18	10				**32**
No							
No response							

Total Respondents	**4**	**18**	**10**				**32**
Are there any other methods used in gold recovery?							
Yes		12					**12**
No	3	2	7				**12**
No response	1	4	3				**8**
Total Respondents	**4**	**18**	**10**				**32**
Is blow torching of the amalgam done in door?							
Yes			1				**1**
No	4	18	9				**31**
No response							
Total Respondents	**4**	**18**	**10**				**32**
Is there a tailings pond in your processing area?							
Yes	4	18	10	4	1		**37**
No				6	3		**9**
No response							
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Do you use gloves during washing							
your minerals?							
Yes	4	18	10	2	1		**35**
No				8			**8**
No response					3		**3**
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**
Is there a waste dumping area in your mine?							
Yes	2	6	3	4	1		**16**
No	1	8	7	6	3		**25**
No response	1	4					**5**
Total Respondents	**4**	**18**	**10**	**10**	**4**		**46**

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