

Mitigating the Activities of Artisanal and Small-Scale Miners in Africa: Challenges for Engineering and Technological Institutions

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Abstract: *The urgent demand for appropriate mitigation of the activities of Artisanal and Small-scale Miners in Africa has become necessary in view of the immense contribution of the mining activities to poverty alleviation in the continent. The concept of appropriate social contract for artisanal and small-scale mining (ASM) emerged amid calls for more humane working conditions for this cadre of miners, whose contribution to the alleviation of poverty especially in the developing nations of the world has been recognized by the United Nations. The sector which is a form of subsistence mining provides a direct or indirect livelihood for over 100 million people in the developing world out of which about 5 million are from Africa. Of particular note is the contribution of this sector to the world supply of strategic minerals for industrial growth and advancement. The presence of ASM is very often associated with challenges, including poor environmental, health and safety practices, the spread of communicable disease, heightened security risks to neighboring communities and operations, child and forced labour, inequitable distribution of benefits in communities and an illegal trade in minerals such as gold, coltan, diamonds, construction materials etc. There is overwhelming consensus that the current worldwide natural resource constraints and the high rising cost of mineral investment and ecosystem pressures require new economic and social contract trajectories which should protect the interests of the Artisanal and Small-scale Miners. These trajectories should address alternatives exploration, mining/processing methods and marketing of vital minerals in an environmentally safe manner while improving the economic status of the miners. It is already the mainstream economy of the future, which is desirable to particularly support the rising African population within the context of sustainable consumption and production patterns. The opportunity exists to make better use of the ASM personnel towards the exploitation of natural resources and use mitigation and adaptation actions as a tool towards a more inclusive development path for the developing countries of Africa. It is in this regard that the contributions of engineering and Technological Institutions are pertinent in terms of training, design and fabrication of appropriate mining and processing equipments that are affordable are adaptable to the African condition and / or geological environment. Although concerted effort is being made particularly by some organs of the United Nations, the paper examines how such mitigations can be further enhanced and accomplished using the expertise and knowledge available in Engineering and Technological Institutions of Africa.*

Key Words: *Artisanal Mining; Small-Scale Mining; Sustainable Development; Mineral Investors; Social Contract.*

I. Introduction

The Africa continent harbours the largest concentration of minerals and presently is the world's largest producer of mineral commodities. The most important issue lacking is the systematic geological mapping which could unveil its vast mineral resources endowments. The countries of Europe are heavily or fully reliant on imports with regard to many critical metals and minerals which African countries are endowed with. At a time when the minerals industry is becoming more and more diversified, there is nevertheless an increased vulnerability to regulatory changes in access to resources, to obstacles in trade and commerce and to major fluctuations in commodity prices (Mallo, 2012). The disheartening trend is that most of Africa's minerals are exported as ores, concentrates or metals, without significant value-addition to the products.

Furthermore, there exist significant resources of fossil fuels (oil, gas and coal) in addition to large potentials for biomass and bio-fuels potential (ethanol, bio-diesel), especially in the tropics. The mineral industry in Africa if adequately harnessed can constitute a formidable source of socio-economic alternative for growth and development. African mineral reserves rank 1st or 2nd for bauxite, cobalt, diamonds, phosphate rocks, platinum-group metals (PGM), vermiculite, and zirconium. More minerals also occur in economic quantity as evidenced by the 2005 share of world production from African soil which showed the following statistics: bauxite 9%; aluminium 5%; chromite 44%; cobalt 57%; copper 5%; gold 21%; iron ore 4%; steel 2%; lead (Pb) 3%; manganese 39%; zinc 2%; cement 4%; natural diamond 46%; graphite 2%; phosphate rock 31%; coal 5%; mineral fuels (including coal) & petroleum 13%; uranium 16% (Mineral Industry of Africa-Wikipedia). Artisanal and small-scale mining takes place throughout the world, but is particularly widespread in developing countries in Africa, Asia, Oceania, and Central and South America. Mining Minerals and Sustainable Development (MMSD) country research studies have been elaborated in the most important ASM countries as Burkina Faso, Ghana, Malawi, Mali, Mozambique, South Africa, Tanzania, Zambia, Zimbabwe, China, India, Indonesia, Papua New Guinea, Philippines, Bolivia, Brazil, Ecuador and Peru. Other relevant ASM countries are Central African Republic, Congo, Ethiopia, Guinea, Kenya, Madagascar, Namibia, Nigeria, Niger, Sierra Leone, Uganda in Africa, Laos, Malaysia, Myanmar, Thailand and Viet Nam in Asia and Chile, Colombia, Dominican Republic, French Guyana, Guyana, Mexico, Nicaragua, Surinam and Venezuela in Latin America and the Caribbean (Thomas Herschel et al, 2002).

The present study however centres on such minerals that attract the participation of the subsistent miners which fall into the category of artisanal and small-scale miners. An array of such minerals is shown in Table 1.

Table 1: Some Leading African Mineral Resources (2005)

| Mineral | Production | Rank | Reserves | Rank |
|------------------|------------|------|----------|------|
| PGMs* | 54% | 1 | 60+% | 1 |
| Phosphate | 27% | 1 | 66% | 1 |
| Gold | 20% | 1 | 42% | 1 |
| Chromium | 40% | 1 | 44% | 1 |
| Manganese | 28% | 2 | 82% | 1 |
| Vanadium | 51% | 1 | 95% | 1 |
| Cobalt | 18% | 1 | 55+% | 1 |
| Diamonds | 78% | 1 | 88% | 1 |
| Aluminium | 4% | 7 | 45% | 1 |

Also Ti (20%), U (20%), Fe (17%), Cu (13%), etc.

PGMs: Platinum Group Minerals Africa's dire need to industrialise is universally acknowledged. The structural transformation of our economies must be an essential component of any long-term strategy to ensure the achievement of the Millennium Development Goals (MDGs) in Africa, eradicate poverty and underpin sustainable growth and development across our continent. The key issue, however, is in the formulation and implementation of workable industrialisation strategies based on our continent's unique strengths, rather than the emulation of strategies that may have been effective in other contexts. A resource-based African industrialization and development strategy must be rooted in the utilisation of Africa's significant resource assets to catalyse diversified industrial development, as was successfully implemented by several erstwhile resource-based economies in the developed world such as in Finland, Sweden, Germany (especially in the Ruhr region), and the US over a century ago and to some extent in more recently in middle income countries Malaysia, Brazil and South Africa (York, 2012).

The artisanal and small-scale mining provides a substantial percentage of the afore-mentioned production. An estimated 13 - 20 million men, women, and children from over 50 developing countries are directly engaged in the artisanal mining sector (<http://en.wikipedia.org/wiki/Artisanal>). As many as 650,000 women in 12 of the world's poorest countries are engaged in artisanal mining, and between 1 and 1.5 million children are also involved in this activity. This explains why artisanal and small-scale mining is exclusively practiced by individuals, groups, families or cooperatives with minimal expertise and technical know-how to exploit the minerals while often depending on the informal (illegal) mineral market which is substantially exploitative. The range of commodities exploited by artisanal and small-scale miners is diverse, including gemstones, gold, copper, cobalt, coltan, coal, construction materials and other industrial minerals.

The term 'Small-Scale Mining' according to Seydou (2001) is the subject of a great debate in the sub-region. Generally, the main criteria commonly used in the attempts to define the precise content of this expression are:

- The physical size of the deposit and the continuity or not of mining activities.
- The organizational structure of the activity and the management system.
- The importance of investment required and turnover generated.
- The number and level of qualifications of the workers involved in the production unit.
- The kind of equipment, degree of mechanization and the level of technology used.

Artisanal mining can include activities as simple as panning for gold in rivers, to as complex as development of sub-surface workings and small-scale processing plants. In any of these circumstances, issues can stem from difficulties in achieving regulatory oversight of a large number of small operations (including issues such as security of land tenure for artisanal miners, to enforcement of environment, safety standards, and labour standards). An artisanal miner or small-scale miner is, in effect, a subsistence miner. They are not officially employed by a mining company, but rather work independently, mining or panning for gold using their own resources. Small-scale mining includes enterprises or individuals that employ workers for mining, but generally working with hand tools. Artisanal miners often undertake the activity of mining seasonally – for example crops are planted in the rainy season, and mining is pursued in the dry season. However, they also frequently travel to mining areas and work year round. Apart from gold and diamonds, other small-scale activities serving for employment for a lot of people center on the extraction of salt, kaolin, silica, sand, brown clay, aggregates and crushed rocks, etc.

The mineral industry is an important source of export earnings for many African nations. In realization of its importance and order to promote exports for these economically vital commodities, groups of African countries have formed numerous trade blocs, which included the Economic Community of West African States, the West African Economic and Monetary Union, Common Market for Eastern and Southern Africa, the Economic and Monetary Community of Central Africa, the Economic Community of Central African States, the Mano River Union, and the Southern African Development Community. In view of their participation in oil production, Algeria, Libya, and Nigeria were members of the Organization of the Petroleum Exporting Countries (OPEC). Furthermore, the African Union was formally launched as a successor to the Organization of African Unity in 2002 with the sole aim of accelerating socio-economic integration and promotion of peace, security, and stability on the continent (en.wikipedia.org/wiki/Mining_in_Africa).

National governments are becoming increasingly aware of the sector's importance as a means of poverty alleviation and a generator of national income. In recent years, a number of governments have formally recognised the sector and attempted to provide facilitating enabling environments. Despite these changes, the implementation of legislation remains

problematic at a local level and many miners do not have faith in the ability or commitment of their governments to provide assistance (Hentschel et al, 2002).

The international development community has been concerned with the artisanal and small-scale mining sector for the past 30 years having identified the sector as a formidable source of ameliorating hunger. As understanding of ASM has increased, the approaches taken have changed. Table 2 summarizes this evolution:

Table2. Historical Evolution of ASM

| Period | Approaches for dealing with ASM |
|--------------------|--|
| 1970's | Definitional issues |
| 1980's | Technical issues |
| Early 1990's | Towards integration of technical, environmental, legal, social and economic Issues |
| 1990's | Special attention on legalisation of ASM sectors |
| Mid to late 1990's | Relation between large mining companies and ASM |
| 2000's | Community related issues and sustainable livelihoods |

Source: Hentschel et al, 2002

II. Methodology

The methodology included two components: analysis of secondary information, and primary research on the activities of artisanal tin mining on the Jos Plateau, Nigeria.

Artisanal Mining in Africa- Country Specifics

The African continent can be described as the hub of major strategic and industrial minerals which the developing countries of the world largely depend on for their industrial growth and development. The contribution of artisanal mining in the production of gold, diamond and tin/tantalum/Columbite and other minerals is provided in Table 3. While this sector contributes to poverty alleviation, it is by no means associated with socio-economic misgivings. Some country specifics on artisanal and small-scale mining are given, thus:

Botswana: Gold has been mined in Botswana for several hundred years, with many old mine workings identified in north-east Botswana. Botswana's gold deposits were relatively small and difficult to mine, and attention soon turned to the much richer South African gold deposits on the Witwatersrand. Exploration and mining in Botswana is governed primarily by the Mines and Minerals Act, 1999 (Cap 66:01). Botswana's policy towards dealing with investors in extractive industries is generally considered to be amongst the best in the world. The legislation governs the ownership of minerals and mineral rights, applications for prospecting licenses, retention licenses, mining licenses and environmental obligations. The Act also addresses the issue of royalties to be paid, license fees and penalties. Other relevant legislation include: the Precious and Semi-Precious Stones (Protection) Act, which provides for the protection of the precious stones industry and regulates dealing in precious and semi-precious stones; the Mines, Quarries, Works and Machinery Act. Botswana's policy provides a stable macroeconomic framework is important, including low inflation and a stable real effective exchange rate. The general policy framework is market-oriented, and supportive of the private sector with focus on revenue sharing/appropriation of mineral rents.

According to Keith Jefferis, 2012, the policy has encouraged the participation of multinational mining companies. For most of this period, De Beers was a public company, listed on the Johannesburg and London Stock Exchanges, although with a major block of shares held by Anglo American. In 2001, De Beers was restructured, and became a privately owned company. As a result, the ownership of De Beers changed to: Anglo American (45%); Central Holdings (Oppenheimer Family) (40%); and Government of Botswana (15%). The restructuring gave the Government an even greater say in the operations of De Beers, and access to significant dividends from De Beers' profits. This success story of Botswana notwithstanding, artisanal and small-scale mining exists in Botswana for the mining of gold, diamond, nickel cobalt etc.

Burkina Faso: According to article 1 of law no. 23-07/II-AN related to mining legislation in Burkina Faso, traditional mining is defined as 'any operation, which consists in extracting and concentrating mineral substances to recover merchant products, using traditional and manual methods and procedures'. Small-scale mining is defined as 'a small size mining having a minimum of fixed facilities, using state of the art semi-industrial and industrial procedures and which is based on prior revealing of a deposit.

Cameroon: In the East Province of Cameroon, an estimated 100 kg of gold is now produced per month by some 10,000 small-scale miners, mostly channeled through informal circuits (Sale 2003). Official figures by the Department of Mines and Geological Research are much lower: approximately 500 kg of gold produced annually by ASM throughout the entire country (Lang 2007). With regard to diamonds, the 700- km border between Cameroon and the Central African Republic has significant diamond production evaluated at 800 carats per month in 1993, despite the inadequate experience of Cameroonians in diamond exploitation (Gweth 2003). In most countries in central Africa, gold and diamond mining remain

artisanal, albeit significant revenue contributors to local and national economies. This informal system can still yield significant socio- economic impact on the Cameroonian economy.

Central African Republic: Artisanal mining of diamonds and gold in the CAR occurs mostly in the regions of Berberati, Upper Kotto, and Sangha. Since 1962, 98% of diamonds and 100% of gold production came from ASM in these regions. The new code includes more attractive fiscal policies and other flexibility that are geared towards deregulating the mining sector and encouraging its development by attracting foreign investors. The Codes are classified into 'Quarry' (construction minerals including sand, gravel and stone) and 'Mine' (all other mineral substances) with permits for exploration and mining falling under six categories: artisanal mine, prospecting, exploration type A, exploration type B, mining, and mine concession (Tieguhong, 2009).

Democratic Republic of the Congo: Conservative estimates are that 2 million people are actively involved in mining and are responsible for producing 90% of the minerals exported from the country. With their dependents, this means 15-20% of the population is directly dependent on this dangerous, illegal activity. ASM, as it is practiced in the country today, is unregulated, hazardous, controlled by illegal traders and security forces, and increasingly marginalized with the advent of new investment in formal mining.

It is not possible to estimate how many people depend on the cascade of economic activity that the miners generate but it is clear that this is the backbone of the trading economy in the DRC today. Twenty percent of the artisanal mining community, or 400,000 miners, sorters, transporters and suppliers, are women. Twice that many are children. The principal mineral being mined is the coltan which is in very high demand by the developed nations especially in the electronic sub-sector.

Ghana: Artisanal and Small scale mining of gold is traced to the 15th Century. □ Prior to 1989, SSM activities, especially gold, was regarded as illegal because of non-existence of legislations to control the activity. □ Thus proceeds from their operations were smuggled to neighbouring countries for sale. Estimated US\$15 million worth of gold from illegal mining was smuggled out in 1985 to neighbouring countries for the activities of artisanal and small scale miners. In Ghana, the regulation of artisanal gold mining is set countries. In a bid to mainstream this activity, Government made a policy decision in 1989 to regularise forth in the Small-Scale Gold Mining Law, 1989 (PNDCL 218). The Precious Minerals Marketing Corporation Law, 1989 (PNDCL 219), was set to promote the development of small-scale gold and diamond mining in Ghana and to purchase the output of such mining, either directly or through licensed buyers. In Ghana the concept of 'small-scale mining' is defined in Mineral and Mining Law 1989

PNDCL 153 as mineral resources mining using methods that do not require heavy investment or the use of sophisticated technologies. In the provisions of 'the small-scale Gold Mining Law', this is defined as gold mining by a group of persons fewer than nine or by a cooperative of more than ten people using methods that do not require neither heavy investment nor sophisticated technologies. The other criteria set by the law are: small-scale mining can be done only by Ghanaians; the maximum period for the licence is five year, renewable; the maximum area for the licence is 10 hectares; the use of explosives is forbidden (Keita 2001).

In 2006, the legal regime of SSM was integrated into the new Minerals and Mining Act 2006, (Act 703). The positive impact of these reforms was that SSM Contributed 23% of total gold production in 2010. By the end of 2010 – ASM sold 776,000 oz of gold, valued at US\$ 797.60 million and 308.679carrats of Diamond valued at US\$ 11.13 million to official agents (Tetteh, 2011). In Ghana, there are about 300 registered small-scale mining groups and they constitute a major source of employment especially for small-scale gold and diamond miners, and contribute some foreign exchange to Ghana's economy. However, there are a lot more of such groups that are not registered, and cannot access any meaningful form of support to boost their business (Adu-Gyamfi, 2011). In all, an estimated 1,000,000 people are directly or indirectly involved in artisanal and small scale mining in Ghana.

Niger: Exploitable deposits of gold have long been known to exist in Niger in the region between the Niger River and the border with Burkina Faso and artisanal gold mining has previously taken place in the area (<http://en.wikipedia.org/wiki/Samira>). The Koma Bangou gold deposit was discovered by ONAREM (l'Office National des Ressources Minières, the Nigerien government's mining company) in 1985. According to articles 43 and 44 of ordinance no. 93-16 related to the mining law in Niger, traditional mining is extracting and concentrating mine stones to recover the useful substance(s) using traditional methods and procedures. Traditional methods apply to mineralization profiles of some substances which have been mined traditionally, or to deposits for which there is evidence that industrial working would not be economically profitable. The Namaga concession upon which the Mine was built is hoped to be the first mine to produce gold from the Tera greenstone belt which surrounds Koma Bangou, the country's largest artisanal mining site.

Mali: Traditional mining has been practiced in Mali and West Africa for a very long time. This is exemplified in the part the Kingdom of Mali in supplying Europe and the Middle East with traditionally extracted gold. Oral and written documents suggest that 12,000 camels loaded with salt would arrive in Timbuktu and when they leave, they are loaded with gold (Keita, 2001). The traditional exploitation concerns mainly auriferous minerals, diamonds and semi-precious stones. As an indication, Kéniéba gold washers have found nice stones and among the most recent discoveries that can be quoted: a diamond jewel of about 299 carats in 1985; a 230-carat diamond in 1990; and a diamond of about 299 carats in 1998.

Concerning the exploitation of semi-precious stones, there was a rush in the Diakon zone in the western part of Mali

between 1994 and 1995. Three thousand people there extracted more than 15 tons of garnet. This uncontrolled production saturated the international market and eventually miners abandoned the sites.

On a regional scale, one can cite the example of the Siguiri Basin in High Guinea where almost 50,000 gold washers produce annually between three and five tons of gold. In 1999, his activity injected \$22 million into the local economy.

The main auriferous deposits, which are the focus of traditional mining, are located mostly in volcano-sedimentary formations (green rocks) of the Birrimian age which are found in two main zones. The first is in the western Bambouck auriferous district with the Sadiola deposit (about 150 tons exploited by Anglo-American Mining Co since 1997, the Yétala deposit (40 tons exploited since September 2001). Additionally, there are the Loulo deposit (40 tons proved), Médinandi (evidence of four tons of gold), Tabakoto (43 tons), Ségala (40 tons) in various phases of certification and development. The second main zone is in the southern auriferous district of Bouré with deposits in Bagoé, Yanfolila, Kangaba and Syama (with 150 tons of gold) worked since 1990. The gold deposit of Morila located in the same district with reserves estimated at 150 tons of gold started production in February 2001.

Mali mining legislation is based on simplicity of equipment used, technologies implemented on the one hand, and on the other hand, the low level of investment required for the operation and non-qualification of workers. Following the recommendation of the national seminar on gold washing, held in Bamako in 1989, where the profession of gold washer was regulated by a special legislation namely ordinance no. 90-09/P-RM of 13 April and its enforcement decree no. 90-186/P-RM of 2 May 1990. The objectives of these texts were on the one hand to legalize gold-washing activities, and on the other to promote small-scale mining of auriferous lodes which are impossible to exploit with large-scale industrial methods and heavy investment. Between 1991 and 1999, traditional mining activities and small exploitations were regulated in several ways. Ordinance no. 91-065/P-CTSP of 19 September 1991 and its enforcement rules included legal provisions related to small-scale mining. Through this regulation, the legislator wanted to correct the weaknesses of former texts and give some importance to small-scale mining. The legislator also specified the parameters to be taken into consideration in classifications. Decree no. 96-214/PM-RM of 16 August 1996 was promulgated for purpose of regulating the collection, processing and marketing of gold.

Nigeria: The artisanal and small-scale mining of gold, tin/ Columbite, lead/Zinc, coal etc has strived in Nigeria at the advent of colonial mining around 1902. In Nigeria artisanal mining practices are unguided and unregulated. Over 95% of mining activities in Nigeria are artisanal and another 95% of these are illegal (this includes minerals such as Tourmaline, Galena, Limestone, Feldspar, Tantalite, Coal, etc Policies in place are inadequate, and miners are untrained and contribute hugely to environmental degradation, and poor quality operational techniques and the loss of minerals. Most activities have proceeded undocumented, resulting in loss of minerals and precious stones. This has caused substantial losses in revenue to the country by way of exports, as well as through royalties and taxes (Mallo 2011). Long before this however, there has been pre-colonial mining of iron ore, gold, tin and construction materials amongst various communities which made them self-sufficient in terms of production of war armaments, jewelry etc. This activity however bourgeoned as a result of commerce introduced by the colonial masters where illegal mining strived along commercial mining of these commodities. This activity reached its peak in the late 1970s the when price of metallic minerals at the international market nose-dived to an all time low prices. The nationalization decree of 1972 further encouraged the activity as major multinational companies exited.

Although there has been a significant leap in terms of mineral reforms in Nigeria, as regards to the new Minerals act of 2007, attention has not been adequately given to the recognition of this informal sector a as formidable source of revenue for government. This notwithstanding, some palliative monetary measures have been extended to small-scale miners through the release of some investment fund in both cash and kind through a World Bank loan. The activities of artisanal miners in Nigeria have caused the lives of people, the Zamfara lead poisoning being the freshest in mind. According to Mallo et al, 2011 and 2012, artisanal mining has contributed to poverty alleviation for tin miners on the Jos Plateau. This has however, not been without corresponding socio-economic consequences to the environment as studied by the Author recently (Fig.1 and Table 3), health of the workers and lose of revenue to the country.

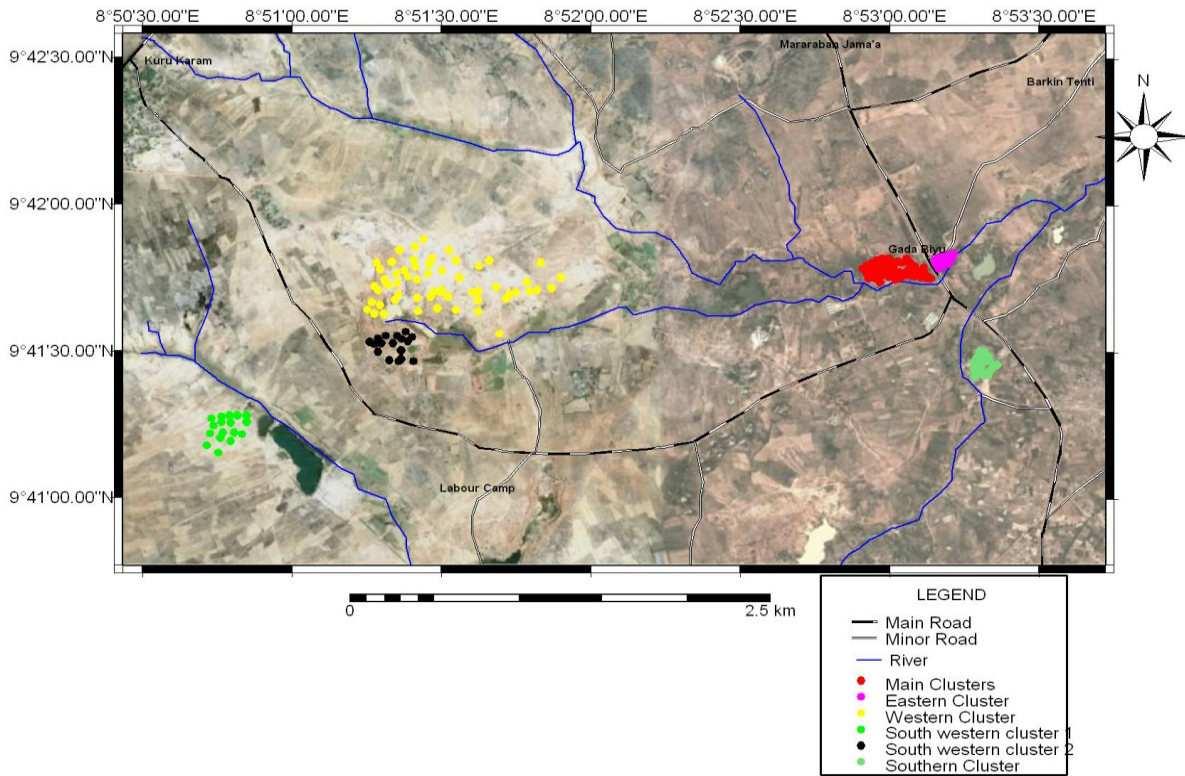


Fig.1. Satellite image showing mining clusters within Kuru and environs: Source Mallo, 2012

Table 3. Locations of Mining Clusters

| S/No. | Clusters | GPS Coordinates | Area of Devastation |
|-------|-----------------------------------|------------------------------|-----------------------|
| 1 | Main Cluster | 9041'46.91"N 8053'00.55"E | 0.334 km ² |
| 2 | Eastern Cluster | 9041'49.37"N 8053'11.62"E | 0.075 km ² |
| 3 | Western (Primary Deposit) Cluster | 9041'43.69"N 8051'30.40"E | 0.600 km ² |
| 4. | Southern Cluster | 9041'26.37"N 8053'18.76"E | 0.194 km ² |
| 5 | South-western cluster 1 | 9041'13.93"N 8053'18.76"E | 0.064 km ² |
| 6 | South-western cluster 2 | 9041'31.11"N 8051'20.03"E | 0.074 km ² |

Source: Mallo, 2012

Tanzania: The activities of artisanal mining of gold and diamond in Tanzania has been extensively studied by Rosemarie Mwaipopo, Wilson Mutagwaba, David Nyange, Eleanor Fisher (2004) and Heschel et al, 2002. Artisanal mining in Tanzania dates back to the early 20th century. Since then, this activity has provided a livelihood for thousands of people. It was difficult work, using dangerous explosives and toxic chemicals. But for 1.5 million Tanzanians, this primitive form of artisanal mining is a daily reality. Yet over time, small-scale miners have adopted harmful environmental practices, with little regard for their own safety. Organized crime has also traditionally been involved in the industry, indenturing countless artisanal miners who have few alternatives. Mining of diamonds is carried out through excavation of shallow pits down to the layer of gravels that contain diamonds. The overburden material covering the diamond bearing gravels contains consolidated black cotton soils. As such, excavation is usually carried out using picks and shovels.

Most pits are shallow and their depth range between 3 – 5m. Once the gravels have been reached, they are scooped using shovels and loaded into buckets that are then hoisted to surface ready for processing. The processing of diamonds is less sophisticated than that used to process gold. At Mabuki, the diamond bearing gravel is panned and thus allowing the heavy diamonds to collect at the bottom of the pan from where it is collected through sorting. As such the processing equipments needed are less sophisticated and include pans and sieves. During the rainy season miners process ore mined during the dry season by using the water that has filled their pits. During the dry season, the shortage of water drives most miners to other activities. However, there are a few deep wells from which processing water is fetched.

These miners rely on knowledge passed down from their parents, and use outdated technology. Most are unaware of fluctuations in the market value of gold, and often sell their gold for a pittance, perpetuating a cycle of poverty.

The mining sector is one of the new pacemakers for growth of the Tanzanian economy. This is evidenced by an increase in its contribution to the GDP from 0.8 percent in 1987 to 2.3 percent in 2000. The target is to raise the contribution of the sector to 10 percent of GDP as new investments come into full operation. However, information on the share of ASM to the mining sector GDP is lacking although it is known that legitimate ASM companies pay 3% of their revenues as royalty to the government hence contributing to the national GDP (Mwaipopo et al 2004). In a study carried out by Heschel et al 2003, for Tanzania, the implementation of a mineral trade liberalization policy in the late 1980s created a more formalized ASM sector. This increased legally traded gold production from US\$0.55m in 1985 to US\$38.78m in 1992.

Zambia: In Zambia ASM is explicitly mentioned in the PRS. As a result key policy objectives regarding the sector are prioritised, allocated and regularly monitored. As a result ASM becomes the interest of a wide range of influential stakeholders; monitored at a national level (Zambia, MFNP, 2003). Possibly as a consequence of its inclusion in the PRS the sector is supported by significant EU and World Bank interventions running into millions of dollars.

Table 4 Artisanal Mining in Africa

| Country | Locations | Commodity |
|--------------------------|--|--|
| Angola | Luali River Area | Gold |
| Burundi | Murehe | Tin, Tungsten |
| Cameroon | Various Locations | Diamond ,Gold |
| Central African Republic | Bandas Greenstone Belt, Bangana Area, Bogoin-Boali Greenstone Belt , Bria Area, Carnot Area , Kotto Area Quadda Area, | Gold Diamond, Gold, Diamond, Diamond, Diamond and Diamond respectively |
| Chad | Mayo Dala Department | Gold |
| Congo – Brazzaville | KellÃ©, Covette-Ouest Department, Likouala Department and Yangadou, Sangha DepartmentÃ | Diamond Diamond, Diamond, |
| Congo – Kinshasa KasaÃ | Occidental Provinces, in Bandundu Province, at Bafwansende and Kisangani in Haut-Congo Province, at Lubutu in Maniema Province, at Kota-Koli, Yakoma, and Gbadolite in Equateur Province), in Nord Kivu Province, and at Luozi in Bas-Congo Province | Diamond |
| Equatorial Guinea | Aconibe, Coro, and Mongomo | Gold |
| Ghana | Birim Valley | Diamond |
| Madagascar | Mananjary, Andilamena and Vatomandry, Ilakaka and Sakara | Emerald, Ruby, Sapphire |
| Morocco | Errachidia, Figuig, and OuarzazateÃ | Barite |
| Niger | Liptako Region | Gold |
| Nigeria | Dutse Nkura, Jos Region , Zamfara,Nasarawa,Birnin Gwari | Tin, Tantulum, Lead. Barite, Gold, |
| Rwanda | Cyangugu ,Nyungwe Forest | Sapphire, Gold, |
| Zambia | Eastern ProvinceÃ, Iteshi Teshi; Mumbwa Kalunga Wbeba, HofmeyerÃ , Katete, Kitwe , Siavunga. | Beryl, Citrine, Tourmaline, Aquamarine, Garnet, Emerald |
| Zimbabwe | Gwanda, Kamativi | Gold Tin, |

Source: Mallo, 2011

Socio-Economic Impact of Artisanal and Small-scale Mining

Activities of artisanal and small scale miners have substantially increased over the last years, in particular in many Asian countries following the financial crises that drove many poor, in particular women and children, into artisanal mining. Today, an estimated 13 million people in about 30 countries across the world are small scale/artisanal miners, with about 80 million to 100 million people depending on such mining for their livelihood. Miners and their families expose themselves to harsh working conditions for minimal income in a high risk context, endangering their health as well as often the surrounding environment. In areas where miners are invading the lands of indigenous or tribal peoples, there can be very serious cultural conflicts, bordering on cultural warfare, also given environmental degradation and diseases brought to these regions by the miners. Meanwhile, much of the actual economic potential is lost due to the absence of a legal or fiscal framework for Small-Scale Mining and due to rudimentary production, processing and marketing techniques. Public or private services to provide essential health care and education typically do not exist. As many as 650,000 women in 12 of the world's poorest countries are engaged in artisanal mining, and between 1 and 1.5 million children are also involved in this

activity. The range of commodities exploited by artisan miners is diverse, including gemstones, gold, copper, cobalt, coltan, coal, and other industrial minerals.

The activities of artisan mining which is mainly clandestine lack statistics on income generated by activities associated with mining. The activity attracts miners and many people like traders, merchants, blacksmiths, cooks and canvassers. The jobs created by artisanal mining operations are important and constitute an important source of income for poor families in mining vicinity and beyond. These jobs are more significant when seen from the social impact standpoint, because they integrate the village's spirit of solidarity with the traditional extended family.

However these gems and minerals that make lives so much easier in the developed world, exact a heavy toll on the people who extract them and on the environment. As the world becomes more aware of the sources of these minerals, the need for a group such as Communities and Small-Scale Mining (CASM) becomes self-evident (<http://www.artisanalmining.org/casm/>) Women working in artisanal and small-scale mining in most African countries face a huge array of issues, challenges and threats. ASM, as it is practiced in the continent today, is unregulated, hazardous, controlled by illegal traders and security forces, and increasingly marginalized with the advent of new investment in formal mining. The men, women and children who carry out this work are indebted, exploited and manipulated for political and financial purposes.

Whilst everyone in the sector faces challenges, the security, health, and social risks posed to women are particularly acute and include:

1. Sexual violence and abuse in the mines, particularly in remote areas where mines are still controlled by military forces. Eastern DRC has the worst rate of rape and sexual abuse in the world, much of which is perpetrated by security forces and militia,
2. Family break-up, polygamy, and abandonment due to the highly migratory nature of ASM,
3. Health risks due to lack of sanitation in camps, malnutrition, and physical trauma from the difficulty of the manual labour. Women in mining camps suffer a high rate of miscarriages due to injury and stress,
4. Exposure to, and involvement in, disruptive and damaging behaviour due to the high levels of alcohol and drug abuse in camps,
5. The risk of HIV/AIDS and other STDs due to prostitution and the risk profile of ASM activities (large concentrations of migratory young men, family separation for prolonged periods, high levels of military presence, lack of awareness, no condom use) and
6. Gender discrimination whereby women do not receive equal pay or opportunities, and are often required surrendering high value products.

Women are frequently obliged to bring their children with them to the mines, and live with them in mining camps. That United Nations agency launched a campaign against children working in mining in 2005, calling it one of the world's worst forms of labour (York 2012). Although some countries like the DRC has ratified the UN Convention on the Worst Forms of Child Labor, and it is illegal for children under 18 to work in mines; however, between 800,000 to 1 million are engaged in artisanal mining. In Mali, an estimated 20,000 children toil in artisanal gold mines, and injury is common. Of 33 child workers interviewed by Human Rights Watch last year, 21 suffered from regular pain in their limbs, back, head or neck, while others were plagued by coughing and respiratory disease. In the Zamfara region of northern Nigeria, about 400 children have died of lead poisoning from the lead-laden rock that they pulverize in search of gold, and thousands of other children need urgent medical care, according to reports by Human Rights Watch and *Médecins sans frontières* (Doctors without Borders). Globally, the number of child miners is probably more than a million. Hazardous underage labour is banned in most countries, yet groups such as the International Labour Organization have struggled in vain to prohibit it.

This exposes them to hazards and health risks, and frequently prevents them from going to school, thereby limiting their future options and the hope for transition to a better life. The activity of artisanal mining in the DRC symbolizes general the conditions such miners are subjected to in most African countries. This is in addition to the tribulations of war.

Artisanal miners exploit over 40 different minerals but gold and diamond typically occupy about 60% of their mining. In DRC and Sierra Leone, artisanal gold and diamond mining make up 75% of national mining production (CASM 2008). Small-scale mines are testimonies for the existence of mineral resources, often pioneering alluvial production close to primary sources that later become industrial discoveries. The small-scale mining operations are also appropriate activities for marginal deposits, where industrial exploitation might not be economically feasible (Gweth 2003).

The social and economic characteristics of small-scale mining fully reflect the challenges of the Millennium Development Goals (MDGs), including: health, environment, gender, education, child labor, and poverty eradication. Small-scale mining communities, for instance, are highly vulnerable to communicable diseases including malaria, tuberculosis, influenza, cholera, yellow fever, sexually transmitted diseases, and HIV/AIDS. HIV/AIDS is not just a public health problem; it is a major development crisis. Because it kills so many adults in the prime of their working and parenting lives, it decimates the workforce, fractures and impoverishes families, orphans millions, and shreds the fabric of communities. Further, large scale mining often comes to areas of traditional artisanal and small-scale mining, which creates potential conflicts around issues of ownership rights and alternative livelihoods, particularly in post-conflict and fragile states which already experience high levels of social and economic stress.

Initiatives for the Promotion of Artisanal Mining in Africa

In an attempt to ensure that Artisanal and Small-scale mining takes place in a sustainable manner Regional and international initiatives have been advanced in order to promote the mining sector, Regional initiatives to promote the small-scale mining sector are more pronounced in the western, eastern and southern parts of Africa. A plethora of international

organizations exist in the mining sector, mostly tackling issues governing large- scale mining rather than dispersed small-scale mining. Some of these major initiatives are presented below:

1. The International Labour Organization (ILO)'s Convention on Safety and Health in Mines, 1995 (No. 176) provides minimum safety standards against which all changes to mine operations should be measured (Walle and Jennings 2001).
2. The International Council on Mining and Metals (ICMM): is a multi-partnership organization that commits corporate members to implement its principles under a sustainable development framework, including global standards, public reporting, independent assurance and sharing best practices. (http://www.icmm.com/sd_framework.php).
3. The World Gold Council (WGC) is a global advocate for gold committed to playing a key role in the development of responsible gold mining. As a member of the ICMM, the WGC seeks to improve sustainable development (http://www.icmm.com/icmm_principles.php). The World Diamond Council (WDC) has a mandate similar to the WGC.
4. The Council for Responsible Jewellery Practices (CRJP) promotes ethical, social and environmental practices throughout the diamond and gold jewellery supply chain, from mine to retail shop (<http://www.responsiblejewellery.com/what.html>).
5. The Kimberley Process was initiated by African diamond-producing countries in May 2000 to develop an international certification scheme for rough diamonds to prevent "conflict diamonds" from entering legitimate markets (Kimberly Process 2004).
This process was supported by the World Diamond Council and the United Nations, and implemented by a UN General Assembly vote in 2003. The certification process follows each diamond from mine through every transfer of ownership to retail sale. The process is supported by a broad range of international stakeholders in the diamond trade, including government officials, industry representatives and non-governmental organisations. Participants officially launched the Kimberley Process Certification The CAR, DRC, Gabon and Republic of Congo are currently participants in the KPCS and in 2007 Cameroon affirmed its intention to join.
6. Extractive Industries Transparency International (EITI): Founded in 2002 encourages governments to disclose their revenues from oil, gas and mining operations, verified by reports of company payments to governments. EITI starts by gaining consent from host governments for reporting their revenues and the payments by companies. Most of the consenting countries have called for disclosure of aggregate company payments across all reporting companies (EITI Fact sheet, 2008).
7. Collaborative group on Artisanal and Small-Scale Mining (CASM): The Communities and Small-scale Mining (CASM) initiative was launched in 2001, in response to a critical need for integrated, multi-disciplinary solutions to the complex social and environmental challenges facing ASM communities, and improved coordination between those working in this sector. CASM is a global networking and coordination facility with a stated mission to "to reduce poverty by improving the environmental, social and economic performance of artisanal and small-scale mining in developing countries." CASM is currently chaired by the UK's Department for International Development and is housed at the World Bank headquarters in Washington, D.C. Resourced by a multi-donor trust fund, CASM currently receives its core funding from the UK and the World Bank, supplemented by program support from Japan, amongst others, Canada, France and the US. Several companies, trade associations and charitable funds, such as Tiffany & Co Foundation, also contribute finances to CASM's work program. CASM funding has leveraged significant additional funding for work in the ASM sector.
8. International Program on the Elimination of Child Labour (IPEC): IPEC, a program of the ILO, includes a sector of activity in "Mining and Quarrying". It notes that child labour "can still be seen in small-scale mines of Asia, Africa, Latin America, and even parts of Europe". The IPEC approach focuses particularly on the development of a solid knowledge base and assessment, and working with partners for delivery of programs.
9. The International Council on Mining and Metals (ICMM). A significant issue in artisanal and small-scale arises when larger mining companies gain rights to develop deposits that are currently worked by artisanal mining. The International Council on Mining and Metals (ICMM) has produced a guidance note for companies engaging with the artisanal and small-scale mining (ASM) sector. As is noted in the introduction to this document "The fact that much of ASM activity occurs In 2009, ICMM collaborated with the Ghana Chamber of Mines and the Ghana Minerals Commission to host a workshop on interactions between companies and ASM in Ghana. This resulted in a report that outlines pragmatic actions for the government, companies and other relevant stakeholders.
10. The Global Mercury Project (GMP): This project was initiated in 2002 when the United Nations Industrial Organization (UNIDO) received \$6.8 million US in financial support from the Global Environment Facility (GEF) and UN Development Programme (UNDP) to initiate the Global Mercury Project (GMP). It was a six-country project (at ASGM sites in Brazil, Indonesia, Laos, Sudan, Tanzania and Zimbabwe), assisting communities along key trans-boundary rivers and lakes in assessing the pollution from current activities to reduce health hazards, introducing cleaner gold mining and extraction technologies to minimize or eliminate mercury releases and develop the capacity and regulatory mechanisms that will enable the sector to minimize negative environmental aspects. Mercury amalgamation is the easiest, cheapest and quickest way to extract gold, but not the most efficient or safest method. When mercury is used in artisanal mining, it escapes into bodies of water as droplets, or is emitted to the atmosphere when the amalgams are heated inadequately. If a retort or fume hood is not used, miners are exposed directly to mercury vapours, which poses an immediate health threat. For the majority of miners, the small income that results from Artisanal and Small-scale Gold Mine (ASGM) outweighs the health risks of using mercury (Sandra Garcia, 2010).

The project aims as well at increasing the knowledge and awareness of miners, government institutions and the public at large on the environmental impacts associated with the application of current technologies. This has been enhanced through introduction of cleaner and efficient technology that apart from minimizing negative environmental impacts will improve earnings, health and safety. (Sandra Garcia, 2010).

11. The UN Department for Economic and Social Affairs: has developed an interesting sustainable livelihood approach for artisanal mining communities, which is currently under pilot implementation in Mali, Ethiopia, Ghana, and Guinea. The main policy recommendations for this approach, according to Labonne and Gilman (1999) are: Mainstreaming poverty eradication into national policymaking in all sectors including minerals; Promoting small-scale mining as a catalyst and anchor for other productive activities to stimulate the development of complementary and alternative productive ventures necessary for sustainable poverty alleviation. Placing people first through both pro-poor strategies and participatory strategies aimed at strengthening the organizational capability of grassroots communities, thereby favouring a bottom-up approach. Reversing the focus from 'hands-on state intervention' (which has rarely been successful) to the creation of private enterprises, particularly microenterprises or cooperatives (Adu-Gyamfi Kwaku (20011); Small scale mining Business in Ghana: challenges and Prospects GhanaWeb)
12. Barrick Mining Company: When large-scale mining came to Tanzania in the 1990s, companies such as Barrick purchased mineral rights from their legal owners. As a consequence, so-called artisanal miners were often displaced from land they held no legal title to. Today, many of them now search for gold in and around the country's large mines, posing numerous safety and environmental risks. In consultation with the community, Barrick has identified key steps that are being implemented in sequence to arrive at regulated, productive and sustainable small-scale mining operations. A mobilization campaign involves educating and informing artisanal communities to build a desire to transform the industry. The aim is to impart a sense of ownership, civic responsibility and entrepreneurial skills to ensure there is a common sense of purpose within the community.

Challenges for Engineering and Technological Institutions

Mining is an engineering discipline that involves the practice, the theory, the science, the technology, and application of extracting and processing minerals from a naturally occurring environment. Mining engineering also includes processing minerals for additional value. Mineral extraction is essential to modern society. Mining activities by their nature cause a disturbance of the environment in and around which the minerals are located. Mining engineers must therefore be concerned not only with the production and processing of mineral commodities, but also with the mitigation of damage to the environment as a result of that production and processing (<http://en.wikipedia.org/wiki/Mining>)

Mining engineers play a key role in the planning, exploitation and excavation of mineral resources. Mining also requires the skills and technology of several other branches of engineering, which is why most of the curriculum for years one and two is common to all branches of engineering such as mechanical, electrical, etc. The third and fourth years focus on mining engineering and include technical valuation, ventilation and environmental engineering, mine transport and rock mechanics. Engineering and technological programme are designed to provide the graduate with the engineering/technological expertise that he or she will require as a mining engineer or a technologist. These institutions can work, in conjunction with one another and in with mining industry, developed a programme designed to cater for the needs of the artisanal and small-scale miners. These include technical subjects for specialist skills in mining, mineral resource management and evaluation, and rock engineering, as well as management skills in evaluation techniques and fundamental mineral economic principles.

The challenges before African Engineering and Technological Institutions is to accept that beside their primary responsibility of the production of high and middle manpower, they are also to consider themselves as agents of positive change within their immediate and remote environment. The institutions must strive to positively bring about changes in the informal sector of the economy by engaging in capacity building of artisans. The institutions must come to terms with the reality that all modern exploration, mining and mineral processing equipments in use in the mineral industry today are the results of centuries of constant improvement and modification from their initial rudimentary stages. The ASM operators will require not very complicated implements/ equipments to improve on their mineral productivity and value addition. The major problems of the ASM are acquisition of mining equipment and basic materials that can enhance their work. The Engineering Institutions can engage in copy technology where simple mining and mineral processing equipment can easily be developed.

Exploration: Mining engineers are involved in the mineral discovery stage by working with geologists to identify a mineral reserve. The discovery can be made from research of mineral maps, academic geological reports or local, state, and national geological reports. Other sources of information include property assays, well drilling logs, and local word of mouth. Mineral research may also include satellite and airborne photographs. Mineral exploration is capital intensive and is capable of writing off millions of dollars without any returns on investments. Engineering and Technological institutions can liaise with Organizations such as those listed above to provide mineral exploration services to artisanal miners. Mining companies can assist the artisanal miners by conceding parts of their mining leases with lower or space concentration of minerals for mining. In doing so the artisanal and small-scale miners can benefit from the mineral data already established by the companies. Large mining companies should acknowledge the important role that ASM plays in the mining sector and provide support where possible, particularly through fostering partnership approaches.

Mining: The act of mining required different methods of extraction depending on the mineralogy, geology, and location of the resources. Characteristics such as mineral hardness, the mineral stratification, and access to that mineral will determine

the method of extraction. Generally, mining is either done from the surface or underground. Mining can also occur with both surface and underground operations taking place on the same reserve. Mining activity varies as to what method is employed to remove the mineral. The artisanal miners lack the technical know-how to scientifically extract minerals either by surface or underground methods. Mining is accomplished a haphazard manner without recourse to safety standards and environmental sustainability. The result is loss of lives due to roof and bench collapses. Furthermore, the sub-surface openings are often very poorly ventilated and lighted leading to mine disasters through suffocation etc. The technological Institutions can embark in the fabrications of underground supports, ventilation networks and effective lightening of sub-surface mine openings in addition to dewatering, mine Haulage, Mine Dewatering, design of Pit Slopes/benches, detection of Rock Failures amongst.

Mineral Processing: Mineral processing methods are critical to the profitability of a mine operation, particularly as customers demand higher production, reliability, efficiency and new features from processing equipment. Some of the most advanced technology in the world for crushing, grinding, washing and separating ores have been developed over a very long time and outside the financial reaches of artisanal and small-scale miners. The institutions are in a position to fabricate affordable crushing, grinding/washing and separation machines. Artisanal and small-scale miners can be trained as lapidarists and empowered with lapidary machines. A *lapidarist* is an artist or artisan who forms stone, mineral, gemstones into decorative items such as engraved gems, including cameos, or cabochons, and faceted designs, or who is an expert in precious stones; and can be a collector of or dealer in gems. Diamond cutters are generally *not* referred to as lapidaries, due to the specialized techniques which are required to work diamond. There are also many other forms of lapidary, not just cutting and polishing stones and gemstones. These include: casting, faceting, carving, jewellery and mosaics. Most lapidary work is done using motorized equipment and resin or metal bonded diamond tooling in successively decreasing particle sizes until a polish is achieved. The development of amalgam retorts should be encouraged to assist the gold miners in effective recovery and minimize the mercury pollution. The essence of mineral processing is value addition and consequently higher selling prices of commodities.

Marketing: Artisanal and small-scale miners are generally poor people whose daily living is dependent on mined commodities. The marketing of minerals by the artisanal miners is generally through the middle-men who stoke in trade is maximum exploitation taking advantage of the financial vulnerability of the miners. Fair-trade initiatives for giving small-scale producers in developing countries the opportunity of trading their products under better selling terms and conditions should be developed where possible. The establishment of Marketing Boards for the purchase of minerals by the government can enhance the marketing value of mineral commodities. Alternatively, collaborative relationships between Mining companies and artisanal and small-scale miners can ensure that minerals mined are purchased at higher value by the companies.

III. Conclusion

Artisanal and small-scale mining is one of the world's fastest-growing industries which trigger the conclusion that for the ASM sector to make the expected contribution to poverty alleviation; serious efforts must be made to break the vicious circle of resource-dependence and poverty. Artisanal mining by its mode of operation which is unscientific is neither legalized nor organized. Artisanal mining in Africa whether is at the tin fields Jos, Goldfields of Zamfara, coltan-fields of the rebel-controlled region of north-eastern Congo, the goldfields of Mali, the Karajipopo cobalt mine in Congo, the goldfields of the East Province of Cameroon, the of Tanzania, the copper-fields of Zambia etc, the Artisanal and small-scale mining (ASM) is a form of subsistence mining, which provides a direct or indirect livelihood for some 60 million people in Africa.

The sector has traditionally received a low proportion of aid relative to its contribution to livelihoods. However, in the last 10 years recognition of the sector's close connection to poverty has increased, and as a consequence and in line with a global shift in concern towards poverty alleviation ASM is gaining more attention. With the exception of few countries like Ghana, Botswana, Mali and Zambia who have made concerted efforts at legislation of the ASM sector, other countries merely pay leap- service to the plight of the miners. Lack of legislation and non-registration with the government deprive these people access to social services. Mindful of the contribution of Artisanal and small-scale mining to poverty eradication, the United Nations has recognized the contribution of this sector. World Bank projects in Bolivia, Burkina Faso, Ecuador, Ghana, Guinea, Madagascar, Mali, Mozambique, Papua New Guinea and Tanzania has attested to this assertion. Furthermore, UN-Organizations as UNDESA, UNDP, ECA, CEPAL, ESCAP, UNCTAD, UNEP, UNIDO and ILO are important multilateral donor agencies that can advance the cause ASM in line with best-practices. By the fastest contributions to the plight of the artisanal miners shall be the contributions of local Engineering and technological Institutions of African nations in ensuring that affordable equipment for exploration, mining and mineral processing are developed and /or fabricated to meet the local needs of the ASMs. The ASM sector must be recognized by Engineering and Technological Institutions as a significant generator of rural livelihoods that has the potential to alleviate Poverty and be a tool for sustainable development. An enhanced fiscal and regulatory frameworks by governments will Ensure sustainable environmental and occupational health management to mitigate risks to the poor within Stabilized macroeconomic/fiscal regimes of African Nations.

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