

Environmental Impacts of Gold Mining in Liberia: A Case Study of New Liberty and MNG Kokoya Gold Mines



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ABSTRACT

Mineral exploitation contributes significantly to economic growth and development in most world economies. In Africa, Liberia is one of the countries endowed with natural resources including gold, iron ore and diamond. The gold mining sector in Liberia consists of both small-scale and large-scale mining, each of which has varying environmental impacts. This paper provides an exposition on the environmental impacts of gold mining activities in Liberia; with primary focus on New Liberty Gold mines in Kinjor, Grand Cape Mount County and MNG Gold mines in Kokoya, Bong County. The data collection mainly involved secondary sources. These included research tools such as review of relevant literature including policies and legal documents as well as review of international documents on the mining sector. The findings from the study showed that mining activities deplete environmental resources such as water, soil, the landscape, vegetation, the ecosystem, among others. The paper concluded that major water bodies in the study regions have been heavily polluted ; land in areas surrounding mines has been rendered bare and susceptible to increased erosion and loss of viability for agricultural purposes, among other uses; increased clearing of vegetation for mining areas has adversely altered the hydrological regimes and/or patterns in the study regions ; important soil organisms have been destroyed and stable soil aggregates disrupted and eventually depriving the soil of organic matter and low levels of macronutrients and soil fertility necessary for plant growth and crop production. This inevitably leads to pending food insecurity in those parts of Liberia, in the long term. On the basis of the above, the paper recommended that there should be effective community participation in environmental decision making to ensure sustainable mining activities; addressing the various weaknesses in the policies and their enforcement in the mining sector; establishment of environmental oversight groups in mining communities; and creation of environmental awareness campaigns and/or education in mining communities.

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CHAPTER ONE

1.0 Introduction

Natural resources such as gold, iron ore and diamond contribute significantly to the economic growth of Liberia (International Monetary Fund, 2014). Although the mining sector of Liberia was heavily hit by the Ebola virus disease (EVD) outbreak in 2014, the sector still remains key to the country's development (Ministry of Finance and Development Planning, 2015). Though Liberia's mineral production is relatively small in terms of its contribution to world output, the mineral sector plays a significant role in the country's economy as a major contributor to the gross domestic product (GDP) and to export revenues. For example, in 2014- the year of the EVD outbreak, gold, diamond and iron ore exports generated more than \$423 million, accounting for about 73% of Liberia's total export revenues. Liberia's nominal GDP in 2014 was estimated to be \$2 billion and the mineral sector remained the country's main source of foreign exchange (International Monetary Fund, 2014). Due to its strategic importance for the socio-economic development of the country, the Mining and Minerals Law of 2000 was enacted to regulate the sector (Wilson *et al*, 2017). Subsequently, the Mineral Policy of 2010 and the 2012 Environmental Protection of Management Laws of Liberia were instituted by the Ministry of Lands, Mines and Energy and the Environmental Protection Agency respectively to compliment the Minerals and Mining Law and further provide guidelines and regulatory framework for the mining sector (USGS, 2014).

Although the mineral sector provides enormous economic benefits to Liberia, the processes involved in mineral exploitation often have some degree of environmental impacts on the communities adjacent the mining projects. This paper provides an exposition of the environmental impacts of gold mining in Liberia with particular emphasis of the MNG Gold mines in Kokoya, Bong County and the New Liberty Gold Mines in Kinjor, Grand Capemount County.

1.2 PROBLEM STATEMENT

Despite the numerous policies, regulations and institutions managing the mining sector, environmental degradation in most of mining communities in Liberia is still of a major threat and concern. Although there are some literatures available on the extent of environmental devastation caused by iron ore mining in Liberia (Wilson *et al*, 2017), not much published data is available on the environmental impacts of gold mining in Liberia. According to Aryee *et al* 2003, the magnitude of damage caused by gold mining largely depends on the mining method being used. Based on this insertion, the current practice of using cyanide to leach gold at MNG Gold and New Liberty mines, in Liberia, raises a lot of concerns amongst environmental technicians and practitioners. Over the past three years, public interest on the topic of environmental pollution has been even more robust due to incidents of cyanide pollution at New Liberty Gold Mines in 2015 and MNG Gold Mines in 2017. Lack of coordination among regulatory bodies; poor cyanide management; inadequate personnel and resources; ineffective community participation; and lack of environmental education and awareness creation have been found as contributory factors to the persistent environmental devastation caused by gold mining in those parts of Liberia.

1.3 OBJECTIVES

The objectives of this research are:

- To describe the gold mining process in Liberia and
- To evaluate the environmental impacts of gold mining in Liberia

1.4 RESEARCH QUESTIONS

In order to meet these objectives, the study will attempt to answer the following research questions:

- Which gold mining and processing techniques are employed in Liberia?

- What are the environmental impacts of gold mining in Liberia?

1.5 JUSTIFICATION OF THE STUDY

In Liberia, gold mining has mainly been done by artisanal and small-scale mining (Wilson *et. al*, 2017). In recent years, focus has shifted to mechanized mining with the opening of New Liberty at Kinjor –Lajor, Grand Cape Mount County and at MNG gold Kokoya, Bong County. With this new trend it is safe to say that Liberia will continue to invest in mechanized mining. Hence, there is a need to evaluate, all of the activities involved with gold exploitation and review its environmental impacts on communities near mines operations. This paper attempts to provides some explanations of environmental impacts associated with mechanized gold mining at New Liberty and Kokoya mines.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 AN OVERVIEW OF GOLD MINING IN LIBERIA

Mining activities in Liberia can be grouped into small-scale and large-scale mining. Small-scale mining usually requires less capital investment and mostly undertaken by small artisans; while foreigners are the main actors of the large-scale mining sector in Liberia. Gold mining can be grouped into three categories (Class A, Class B and Class C). Class A is mechanized mining whilst the other two categories require less machinery use (USGS, 2014).

There are currently two Class A gold mines in Liberia: New Liberty Gold Mines in Kinjor, Grand Cape Mount County and the MNG Gold Mines in Kokoya, Bong County; both owned by MNG Group of Companies (Wilson *et al*, 2017).

2.2 MNG Gold Mines

The Kokoya Gold Mine is located 167 km northeast of Monrovia, the capital city of Liberia. Operations commenced in 2016 with a capacity of 650,000 tons per year and an average expected output of ninety-five percent. The project is primary a vein-hosted gold deposit with a declared indicated mineral resource of 1.84 Mt at a grade of 3.4 g/ton and an inferred resource of 2.7 Mt at a grade of 1.95 g/ton according to a 2014 feasibility report by Design Engineers Limited.

The Government of Liberia, through the Ministry of Land, Mines and Energy in January of 2015, issued a Class A Mining License for MNG to exploit the gold bearing ore under the terms of the Mineral Development Agreement (MDA) with the aim to:

- Procure and maintain the most advance technology in the sector

- Employ and maintain good occupation health and safety practices or standards across all of its operations
- Contribute to national development
- Provide local prosperity and respect the local environment at all times during its operations

The company operates an open pit mine in Kokoya and employs a processing technique known as Carbon-in-Leach. This technique makes use of cyanide to leach gold from its ore. According to a 2014 report by Mining Data Solutions, the life span of the Kokoya Mines is expected to elapse by 2022.

2.2 NEW LIBERTY GOLD MINES

The New Liberty Gold Mine, one of the two largest gold mines currently in operation in the Republic of Liberia, is found in Grand Cape Mount county in North Western Liberia, approximately 90 km northwest of the capital Monrovia. The Mine is situated within the Bea-MDA property which covers an area of 457 km² (USGS, 2014).

The Government of Liberia in July of 2009 granted a Class A License to Bea Mountain Corporation (Bea), a fully owned subsidiary of Aureus Mining Inc, subject to annual license fees, equity interest and royalty in order for the country to gain revenue and benefit from its extractive resources. According to AMC Consultant, at the time of the MDA the area has been subjected to limited surface artisanal mining and has had no historic environmental issues.

Mineralization at the mine comprises of Upper Archean to Lower Proterozoic greenstone belt-hosted lode gold deposits. Resource estimation shows that the mine has a measured mineral resource of 651 Kt at 4.77 g/t, an indicated resource of 9,145 Kt at 3.55 g/t and an inferred resource of 5,730 Kt at 3.2 g/t with a cut-off grade of 1.0 g/t (AMC Consultant, 2010). Mining techniques

currently employ at the mine uses open pit method, and the life of the mine is placed at eight and the half years. Gold from the mine was first poor in 2015 and Commercial productions at the mine began in March of 2016.

2.3 MINERAL LEGISLATION

The Ministry of Lands, Mines, and Energy (MLME) is the Government Agency responsible for the administration of the mineral and mining sector, including granting mining licenses, and it has statutory oversight of the energy, land, minerals, and water sectors. The minerals and mining sector is regulated by the Mining and Minerals Law of 2000 and Exploration Regulations (MLME 2010). The Minerals Policy of Liberia was created in March 2010 to complement the Mining and Minerals Law. These documents outline the Government's expectations with regard to the contributions of all stakeholders in the sustainable development of Liberia's mineral resources. These laws are under review, but outline five types of mining licenses (Table 1). In addition to the mining licenses, there is a Mineral Development Agreement (MDA), which sets out the basis to acquire a class A mining license. The MDA sets out in detail the operational and fiscal terms for both exploration and mining and to ensure a straightforward transition from exploration to the mining phase of the operation provided that the operator has complied with the general provisions of the law. In negotiating an MDA, the Minerals Technical Committee has discretionary authority regarding those matters which are subject to the regulations, which together with the law specify principal terms and conditions.

Table 1: Types of Mining Licenses, land size and duration in Liberia (Sources: MLME-Mineral and Mining Law 2000; LEITI Report 2016)

License	Description	Validity Period
Prospecting License	It is granted when an area has not already been subject to a valid mineral right granted to another person; the area granted shall not exceed one hundred (100) acres. The holder shall file and submit to the Minister of Land, Mines, and Energy a proposed work plan for the prospecting. The prospecting license does not give the right to conduct commercial mining.	Six (6) months, renewable once for a further period of six (6) months provided that the holder meets his obligations under the law
Exploration License	It is granted when the area has not already been subject to a valid mineral right granted to another person; the exploration area shall be contiguous and shall not exceed one thousand (1000) square kilometers. The holder is to submit a proposed exploration program to the Minister of Land, Mines, and Energy within ninety (90) days after the issuance of the exploration license and shall commence exploration within one hundred and eighty (180) days after the issuance of an exploration license unless the Minister agrees to a longer period	Not more than three (3) years and it may be extended for a single two (2) year term upon written application of a holder
Class C	The production area covered by this license shall be not more than twenty-five (25) acres. One person may hold up to four (4) class C mining licenses at the same time. Holders of a class C mining licenses shall conduct mining predominantly as a small-scale operations.	One (1) year, renewable for further terms of 1 year each, if the holder has met all of his legal obligations
Class B	Holders of a class B mining licenses can conduct mining as industrial operations. Production area is twenty-five (25) acres	Five (5) years, renewable for not more than five (5) years.
Class A	It is granted during or at the end of the exploration period of a discovery of exploitable deposits and is materially in compliance with, a Mineral Development Agreement, which has become effective, permitting mining in the proposed production area.	Not be more than twenty-five (25) years and may be extended for consecutive additional terms not exceeding twenty-five (25) years each.

2.4 REGULATORY FRAMEWORK

The principal agency for the management of the environment in Liberia is the Environmental Protection Agency (EPA). The Environmental Protection Agency Act of Liberia (EPA 2003) mandates the EPA to coordinate, monitor, and supervise all activities in the field of the environment. The EPA makes mandatory to file an Environmental Impacts Assessment (EIA) and Environmental Impacts Statement (EIS) to obtain government approval prior to initiating activities. In the case of the mining sector, an EIA declaration format has been specifically designed for mining activities. The EIA has five component phases: namely, project screening; scoping; description of the project/action, alternatives, and environmental baseline; identification of environmental impacts; environmental management plan/design of corrective measures; and monitoring and control. This EIA process is similar to other EIA processes worldwide in that the EIA is a process that analyzes and evaluates the impacts that human activities can have on the environment. Also, its purpose is to guarantee a sustainable development that is in harmony with human welfare and the conservation of ecosystems; thus, proven itself to be an effective tool in environmental planning and management (Wathern, 1994).

2.5 ENVIRONMENTAL CHALLENGES ASSOCIATED WITH MINING

The laws in place for mining operations in Liberia, therefore, tend to be broad and ineffective. Additionally, there are overlaps and conflicts between different pieces of legislation (e.g., Public Procurement and Concession Act and the Minerals and Mining Law of 2000) that govern the sector. Furthermore, data collection is mainly carried out by various governmental bodies concerned with environment protection and policy (Forestry Development Authority, Ministry of Lands, Mines, and Energy). Besides, basic environment statistics such as water resources (surface and ground water abstraction, water used by sectors, freshwater availability, precipitation,

evapotranspiration, water quality, river inflow/outflow) and land degradation information are mostly not available. Some available data are of limited time and geographical coverage. Those data often result from case studies or projects of limited duration. After the study or project ended, data collection usually stopped. Other available data are not up-to-date; consequently, hindering data collection and reporting processes. The lack of adequate logistics, personnel, and funding also constrain proper governance, particularly in relation to field monitoring and technical audit functions.

Water use in the mining sector and its associated environmental impacts has not been properly investigated. Although, the large-scale mines are in their early stages of operations and are located in and around major river courses and its tributaries. Presently, the gold mines in Liberia use cyanide in the recovery process. Cyanide leaching is the standard method used for recovering approximately 83% of most gold throughout the world today (Karahan *et al.* 2006). Also, the uncontrolled management of cyanide when comes in contact with waterways has serious environmental and health consequences. In recent time there has been public outcry by local mining communities of contaminated drinking water sources (streams, creeks) from mining concessions in the country.

Water resource management is one of the greatest global challenges of the twenty-first century (Hoekstra *et al.* 2009). The mining industry and water resources are critically linked; mining needs substantive amounts of water to proceed but can also have major impacts on surface and ground water resources. Given water's primary role in sustaining ecosystem, communities, and economies, the mining industry is recognizing the challenges posed by sustainable water resources management and is embracing the opportunities it presents (Mudd, 2008). In contrast to the

abundance of mineral wealth in Liberia, water resources are vulnerable to environmental impacts from mining activities. Unless appropriate corrective actions are taken, the mining sector is expected to place further degradation on the country's undeveloped water resources.

For mining projects, there are a number of factors that can affect the embodied water of a metal or mineral output, including climate conditions; primary water source: surface water, ground water, or saline water; ore mineralogy and geochemistry (especially as this affects processing); tailings and waste rock/overburden management; type of commodity; the extent of re-use and recycling; mine-site water management regime; surrounding communities, land uses, and/or industries; project design and configuration and surrounding hydrogeological conditions (Mudd 2008).

2.6 GOLD MINING TECHNOLOGIES AND PROCESSES USED IN LIBERIA

Currently there are two large-scale industrial mines operating in Liberia with several others into exploration and mine development (Table 2). Open Pit mining method is generally employed by the operators. The ore is extracted from the mine and processed through the plant to produce a concentrate. Tailings, or waste material, are then deposited in a tailing storage facility (TSF) .

Table 2: Large-scale gold mining companies in Liberia (Sources: MLME-Mineral and Mining Law 2000; LEITI Report 2016)

Mine/Company	MDA Agreement	Production	Ore grade
Kokoya/MNG	2004; 25 years	619.48 K oz Au	3.54 g/t Au
New Liberty/ MNG	2002; 25 years	2376.45 Koz Au	4.17 g/t Au

In open pit / open cast mining, over-burden material (soil and surface rock) is stripped and stockpiled. The mineralized zone is then mined preferentially although ongoing removal of waste rock will typically continue to some extent throughout the life of mine. Open pit / open cast mining

employs relatively straightforward excavation techniques. The rocks are drilled and blasted and the broken materials are loaded onto haul trucks and transferred to stockpiles (ore or waste rock) or directly to a surface processing plant (Wilson *et al*, 2017)..

At the processing plant, a technique known as Carbon-in Leach (CIL) is employed to leach the gold from its ore. A Carbon In Leach process recovers about 85% to 95 % of gold. The ore from the mines is first grind into fine mills and mix with water to form slurry. From the ball and/or autogenous mill, slurry is pumped to the CIL leach tanks where lime adjusts the pH, if necessary, and it is agitated for the desired period of time. Air is added to increase the reaction rate and shorten the leach time. Cyanide is added, typically in the first tank. Each carbon leach tank has a inter stage screen in it for carbon retention. Slurry can gravity flow between tanks or be pumped. Aureus and MNG Gold use 6 tanks each. From the first tank, the loaded carbon is pumped using a recessed impeller pump (to not degrade the carbon), or another suitable type of pump, to a loaded carbon screen, where the slurry passes through the screen and retains the carbon.

From there the loaded carbon may be acid washed to remove material, such that might interfere (take longer) for the carbon stripping process. After the acid wash, the acid is neutralized with sodium hydroxide. Then the carbon is sent to the carbon stripping process. The stripping solution is typically a heated solution of cyanide and sodium hydroxide. Stripping can take a couple of hours. Then, the pregnant concentrated solution is pumped to the electro winning cells, where the gold is plated onto the cathodes, which are steel or stainless steel wool. These mining and mineral processing technologies require sufficient energy, water, and chemical reagents as sources for operations; thus polluting groundwater, watercourses, and habitats from spills and leakages of toxic or hazardous substances significantly (Wilson *et al*, 2017).

CHAPTER THREE

3.0 METHODOLOGY

3.1 STUDY AREA

The case study was conducted using both New Liberty hold mines and Kokoya gold mines. The New Liberty gold mines is situated in Golakonneh District, Grand Cape Mount County; approximately 100 km North-West of Monrovia, the capital of Liberia.

The MNG gold mines is located in Kokoya District, Bong County; approximately 167 km northeast of Monrovia, the capital city of Liberia.

3.2 SAMPLING DESIGN AND DATA COLLECTION

The study employed a purely secondary research approach, where data was primarily collected from review of existing literature. The secondary data used in this study included a critical review of literature on environmental impacts of mining in Liberia, and a review of relevant laws and regulations currently in force. These also included international treaties and other documents or publications relating to standard international best practices of environmental protection.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This section presents the results of the study and their discussions, with a view to drawing logical conclusions from the findings. The environmental impacts of mining activities are discussed based on their implications on various aspects of environmental resources, namely: impacts on water quality, ecosystem/loss of vegetation, soil quality, and on the land resource. Also, some contributory factors to the persistent environmental degradation in the study area are briefly discussed.

4.1 ENVIRONMENTAL IMPACTS

4.1.1 IMPACTS ON WATER QUALITY

This paper reviewed water quality data from a study conducted at the MNG Gold, Kokoya by SGS (2017) and compared the results of selected parameters with the initial baseline data of the concession area, as reported by Golder (2015). The results of the comparative study are presented in Table 3.

Table 3: Comparative Analysis of water quality baseline data (Golder, 2015) and SGS report (2017) for selected sampling points in and around MNG gold mines, Kokoya

Parameter (Unit)	Sampling Point/ Code	Golder Report (2010)	SGS Report (2017)
pH	GW-1	7.6	5.8
pH	SW-1	7.5	5.6
Total Cyanide (ppm)	GW-1	0.0	0.92
Total Cyanide (ppm)	SW-1	0.0	0.86
Arsenic (ppm)	GW-1	1.30	1.40
Arsenic (ppm)	SW-1	1.20	0.90
Mercury (ppm)	GW-1	0.50	0.71
Mercury (ppm)	SW-1	0.40	0.90

The result shows a significant decrease in pH of the water samples over a space of seven years. This shift to acidity may be largely due to acid mines drainage around the MNG gold mines. The

result of total cyanide also showed a marked increase in total cyanide levels in surface and ground water across the study area. This increase may be due to the company's use of cyanide to leach gold. Arsenic levels remained relatively unchanged from the two reports. The levels of mercury increased from baseline conditions observed in 2010. This may be a confirmation of the use of mercury by artisanal miners around the concession area.

Review of other literature and ESIA documents from the study area revealed that major water bodies in the area such as Mafa (in Golakonneh) and Sien Creek (in Kokoya), which used to serve as the main sources of water for domestic purpose in the surrounding townships, had been heavily polluted by mining activities especially those of illegal small-scale mining. Mining, especially surface mining, results in adverse environmental impacts on water bodies (rivers and streams) in Liberia through the release of effluents such as mercury, arsenic and solid suspensions. Moreover, a study by SGS (2017) revealed that between 2015 and 2017, two major cyanide spillages and leakages occurred (one at each of the gold mines) resulting in contaminating some major water bodies near the concession areas. This led to a significant loss of aquatic organisms, displacement of people, and a depletion of livelihood and drinking water for some communities.

Also, a review of ESIA documents have shown that the mining operations especially that of the illegal small scale mining are carried out in the open air without appropriate safeguards and environmental standards, and in the process releases contaminated water into the surrounding environment, thus polluting nearby rivers, soils and vegetation . This agrees with the findings by Hilson (2002) who found in his study that approximately 5 tonnes of mercury emission is being released each year into various water bodies by small-scale mining artisans leading to siltation and coloration. He further added that apart from siltation and coloration of water bodies, mercury

discharge also leads to de-oxygenation, death and destruction of aquatic organisms and their physical habitat, thereby hampering their growth and ultimately decreasing their population.

4.1.2. IMPACTS ON ECOSYSTEM/LOSS OF VEGETATION

Concerning impacts on the ecosystem, a review of ESIA documents showed that greater proportion of the land area have been rendered bare due to mining activities in the two areas. Large tracts of land in many areas such as Ndablama, Lanjor, Kinjor, Saywehn Town and Davide Dean's Town among others, have lost their vegetation cover as a result of mineral mining. The resultant repercussions are massive gullies, excessive run-off, heavy erosion, reduced soil infiltration, reduction in groundwater recharge and consequent loss of land productivity. This has culminated in the destruction of the luxuriant vegetation, biodiversity, cultural sites and water bodies.

4.1.3. Impacts on Land

Mining, independent of the scale and method of operation, results in substantial damage to the landscape if appropriate regulations are not put in place and enforced rigorously. Considerable areas of land and vegetation in many mining communities in Liberia have been cleared to accommodate surface mining activities. A review of ESIA documents revealed that the gold-mining operations have caused a disproportionate amount of damage to the lands in these areas. Most of the underground operations, especially in the small scale mining, appeared to be constructed haphazardly, excavated to unsafe depths and supported flimsily by logs and branches. Furthermore, huge patches of forest have been cleared in certain areas to establish resting grounds for miners. Such practices had also played a major role in altering the local hydrological patterns in around the two study areas (Mensah, 2015).

4.1.4. IMPACTS ON SOIL QUALITY

Another area where mining has a devastating effect on the environment in Liberia is the soil. Many research findings indicate that soils are adversely affected by surface mining [32]. Since mining in the study area makes use of heavy machinery and involves blasting during the mineral's extraction, important soil organisms have been destroyed, stable soil aggregates disrupted, and eventually depriving the soil of organic matter. These soils, or newly created substrates/growth are often inhospitable to vegetation due to combination of physical, chemical and microbiological factors (Mensah, 2015).

4.1.5 IMPACTS FOR MINES ACCIDENTS IN LIBERIA

One of the major environmental impacts of gold mining comes in the form of tailings. Tailings are a slurry residue waste product generated as from ore milling and processing operations in mining. They are typically treated through physical or chemical means before being passed by pipeline to a Tailings Storage Facility (TSF). TSF are containment facilities and are most commonly either a dammed and backfilled natural valley or "dry stack" stockpiles. In some locations where the landscape is flat, tailings are stored within constructed earth bunds. Tailings dams may impact the environment through leaching of acids and / or heavy metals into surface and / or groundwater resources and /or through dust blowing off them. Tailings dams are often unsightly features in the landscape.

In October, 2015, the TSF at New Liberty Gold Mine was overwhelmed, following a heavy down pull of rain, releasing cyanide containing slurry into the nearby Mafa River. This resulted into death of fishes and contamination of the surface water. The downstream community of Jakaindor was greatly impacted by this situation (IRIN, 2017).

Similarly in September, 2017, the North West embankment of the TSF at MNG Gold collapsed, following heavy down pull of rain. This incident caused the release of thousands of gallons of cyanide containing slurry into the nearby Sien creek and adjacent wetland. This resulted in the loss of biodiversity in the area (SGS, 2017).

CHAPTER FIVE

5.0 CONCLUSION

Dealing with the inherent issues of environmental degradation in the face of mining activities is a delicate balanced one indeed. This paper examined the environmental impacts of gold mining in two concessions in Liberia (New Liberty and Kokoya) The paper concludes using the SWOT analysis by outlining the strengths, weaknesses, opportunities, and threats of gold mining in the study area.

5.1. STRENGTHS

Gold mining has significant benefits to the mining communities in Liberia as it contributes to their economic growth and development. The sector, particularly the large scale mining, has also employed a sizable number of workers. It is also as a result of surface water pollution that the government had embarked on digging boreholes for some communities to access water for their domestic use. In addition, surface mining which is the dominant method of mining used by small-scale mining artisans is cost effective due to its minimal capital and technical investments. The sector has therefore contributed significantly to the socio-economic development of the country.

5.2. WEAKNESSES

Among the weaknesses include the methods of mining employed in the area. Open pit mining which is the dominant method has rendered vast lands surrounding the mining communities bare. This has made the land susceptible to increased erosion and loss of viability for any agricultural purposes, among others. Also, the clearing of vegetation for mining areas has adversely altered the hydrological regimes in the region. Low entry barriers for mining companies, ineffective

community participation and improper research methods are other weaknesses to environmentally sustainable mining in the region, in addition to weak legislative and institutional frameworks.

5.3. OPPORTUNITIES

There is a great opportunity to improve and enhance the application of the numerous policies and regulations governing the mining sector in Liberia. This stands to regularize and monitor the mining sector and curtail the mushrooming of several illegal mining activities. A deliberate and coordinated environmental education and awareness creation by relevant institutions is another opportunity available to educate mining entrepreneurs and the general public on the provisions of the law and imperatives of sustainable environmental management. This will go hand in hand with effective community participation in the articulation of these requirements.

Furthermore, there is vast opportunity to reclaim and rehabilitate abandoned mining pits by both large and small-scale miners in order to curb further degradation of the landscape and finally revert these lands to further productive use.

5.4. THREATS

Mining activities, especially the use of cyanide, have posed significant threats to major water bodies near the two concession areas under review. Many of these water bodies have been heavily polluted due to mining, especially those of illegal small-scale mining. The communities in these mining areas therefore spend huge sums of money to access, treat, and store groundwater for their domestic and other uses. This is a threat to their economy and livelihoods. Also, the removal of the topsoil which destroys important soil organisms and disrupts stable soil aggregates and organic matter have been other significant threats to the productive use of the land. Most mining sites in

the study area exhibit low pH and low levels of soil macronutrients such as Nitrogen and Phosphorus that are necessary for crop production (Sheoran *et al*, 2010).

In addition, the search for new mining sites is taking over the available land and thus reducing the size of suitable and usable land in the area. Mined pits left unfilled renders land unsuitable for any other purpose and also become threats to both human and animal health, as they store water which provides breeding grounds for malaria-infected mosquitoes (Sheoran *et al*, 2010).

CHAPTER SIX

6.0 RECOMMENDATIONS

Upon a detailed analysis of the current situation of gold mining at New Liberty and Kokoya, the study came up with the following recommendations to minimize environmental impacts associated with gold mining in Liberia. The recommendations mainly focused on the current situation in the study regions.

6.1. ENSURING EFFECTIVE COMMUNITY PARTICIPATION IN ENVIRONMENTAL DECISION MAKING

Effective community participation in environmental decision making is necessary for contemporary natural resources management practice, and is the cornerstone of responsible and democratic environmental governance and a fundamental prerequisite to achieving sustainable development. Such participation should move beyond traditional methods of public consultations by creating opportunities for open exchange of ideas, transparency, mutual learning, and informed and representative decision-making processes. The participation is also according to the Rio Principle Number 10 (usually referred to as “participatory principle”) which stressed, among others, that “environmental issues are handled best with the participation of all concerned citizens, at the relevant level” (UNCED, 1992). This participatory principle addresses the legal position of individuals and civil society organizations by affirming procedural rights of access to information, public participation and access to justice in environmental policy.

Projects which normally tend to deprive the affected communities of their involvements become “white elephants” and therefore become unsustainable. Effective community participation will therefore protect project interests, promote democracy, improve project legitimacy, increase accountability of projects, enhance project quality, enhance effectiveness of the ESIA process,

reduce conflicts associated with mining projects between mining companies and the affected communities, and help in effective environmental decision making and thereby ensures the sustainability of mining activities.

6.2. ADDRESSING THE WEAKNESSES IN THE MINING ENVIRONMENTAL POLICIES AND ENFORCEMENT

The government should address the weaknesses in environmental policies on mining and strengthen their enforcement in order to realize sustainability of the environment. In the absence of effective environmental governance and regulatory framework, sustainability is difficult to realize, since the policies provide the mechanisms for regulating overall environmental behavior. Environmental policies and their enforcement are actions taken to manage human activities with a view to preventing, reducing, or mitigating harmful effects on nature and natural resources. The enforcement of regulations ensures that human activities on the environment do not have harmful effects on humans and the physical environment.

6.3. ESTABLISHMENT OF ENVIRONMENTAL OVERSIGHT GROUPS IN MINING COMMUNITIES

There is need to establish environmental oversight groups with a singular mandate of protecting the environment in mining communities as a local initiative and a bottom-up approach in getting community members engaged in environmental governance.

6.4. ENVIRONMENTAL AWARENESS CAMPAIGNS AND/OR EDUCATION IN MINING COMMUNITIES

There is need to create environmental awareness campaigns and/or education in various mining communities as a means of ensuring sound and sustainable use of the environment in the face of

on-going mining activities. This will create the necessary balance between development/economic growth and mandatory environmental exigencies for community livelihoods.

The above recommendations will help enhance sustainable mining and forestall the environmental impacts that undermine the sustainability of the mining and environmental policies towards achieving environmental sustainability in Liberia.

REFERENCES

- Aureus Mining (2014) ESIA update for the new liberty gold mine in Liberia: ESHS submission and update specialist reports
- EPA (2003) Environmental Protection Agency Act of Liberia. Liberia
- Golder (2015) Environmental baseline report of MNG gold mines, Kokoya
- Hilson G (2002) The environmental impact of small-scale gold mining in Ghana: identifying problems and possible solutions. *The Geographical Journal* 168(1): 57–72
- Hoekstra AY, Chapagain AK, Aldaya MM, Mekonnen MM (2009) Water footprint manual: state of the art:2009
- IRIN (2017) How a gold mine has brought only misery to Liberia
- LEITI (2016) LEITI report for the year ended 30 June 2015. *Liberia Extractive Industry Transparency Initiative, Liberia*
- Mensah AK (2015) Role of revegetation in restoring fertility of degraded mined soils in Ghana: A review. *International Journal of Biodiversity and Conservation* 7(2): 57–80.
- Ministry of Finance (2013) Annual Economic Review, Republic of Liberia
- MLME, (Ministry of Lands Mines and Energy) (2010) Mineral policy of Liberia. Liberia
- Mudd G (2010) The ultimate sustainability of mining: linking key mega-trends with 21st century challenges. In: sustainable mining 2010 conference. AusIMM, Kalgoorlie, pp 351–373

SGS (2017) Environmental Hazard Investigative report

Sheoran V, Sheoran AS, Poonia P (2010) Sheoran, V., Sheoran, A. S., & Poonia, P. (2010). Soil reclamation of abandoned mine land by revegetation: a review. *International Journal of Soil, Sediment and Water* 3(2): 13.

United Nations Conference on Environment and Development (1992) Rio de Janeiro, Brazil, 3 to 14 June 1992

USGS (2014) Mineral Yearbook-Liberia, 2014

Wathern P (1994) Introductory guide to EIA. In: *environmental impact assessment; theory and practice*. Unwin Hyman, p 1