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Environmental Impacts of Mining: A Study of Mining Communities in Ghana

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Abstract Mineral exploitation contributes significantly to economic growth and development in most world economies. In Africa, Ghana is the second largest gold producer, contributing to about 5.7% of the country's GDP. The mining sector in Ghana 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 mining activities in Ghana. The paper mainly focused on the mining activities in Prestea in the western region of the country. The data collection involved both primary and secondary sources. These included research tools such as review of relevant literature including policies and legal documents, participant observation, in-depth interviews with mining communities and government officials, environmental assessments of various mining sites in the study area. The findings from the study showed that mining activities, especially that resulting from illegal small-scale mining (popularly known as *'galamsey'*) deplete environmental resources such as water, soil, the landscape, vegetation, the ecosystem, among others. The paper concluded that major rivers in the region have been heavily polluted, especially by illegal small-scale mining; 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 western region of Ghana; 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 most parts of Ghana, 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; easing of the registration process for small-scale mines; addressing the various weaknesses in the policies and their enforcement in the mining sector; establishment of environmental oversight groups in mining communities; and create environmental awareness campaigns and/or education in mining communities.

Keywords: *Ghana, Prestea, gold mining, environmental impacts, community participation*

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1. Introduction

There is no doubt that natural resources such as gold, diamond, bauxite, and crude oil deposits can contribute significantly to economic growth and development, of which Ghana is no exception [4,19,40,42]. Ghana, formerly known as Gold Coast, is the second largest gold producer in Africa and the ninth in the world, contributing about 40% of the country's gross foreign exchange earnings, an equivalent of about 5.7% of the country's GDP. Due to its strategic importance for the socio-economic development of the country, the mining sector was one of the priority areas of the country's Economic Recovery Program in 1983 [4,10,16,19,22]. Consequently, new minerals and mining laws were enacted and the Ghana Environmental Protection Agency and Minerals Commission were instituted to provide guidelines and regulatory framework for this sector. Table 1 presents historically, the contribution of the mining sector to government revenue, value added and employment in Ghana.

1.1. An Overview of Mining Activities in Ghana

Mining activities in Ghana can be grouped into small-scale and large-scale mining. Small-scale mining (Plate 1a) usually requires less capital investment and mostly

undertaken by small artisans; while foreigners are the main actors of the large-scale mining sector in Ghana. However, small-scale mining activities are statutorily restricted to only Ghanaians. The government and private Ghanaian investors account for less than 15% of the shares in the mines [3].

Table 1. The Contribution of Mining to Government Revenue, Value Added and Employment

Year	Total Government Revenue [b]	Percentage of Economy-Wide Value Added	Percentage of Industry [c] Value Added	Percentage of Economy-Wide Employment	Percentage of Industry Employment
1960	-	5.8%	18.3%	1.9%	11.4%
1970	-	5.2%	15.9%	1.0%	6.4%
1980	-	2.6%	10.2%	0.6%	3.4%
1990	8.9%	2.9%	14.1%	0.9%	6.1%
2000	13.7%	2.8%	14.6%	1.8%	11.6%
2010	21.3%	2.9%	14.4%	1.1%	7.4%

Source: 10-Sector Database published by the Groningen Growth and Development Center (GGDC) for the period 1960-2010.
a Figures are Minerals Commission, Statistical overview of Ghana's Mining Industry (1990-2003); Internal Revenue Service/ GRA (2004-2011)
[b] Industry as defined here includes Mining, Quarrying, Manufacturing and Construction.

Plate 1a. Illegal small-scale mining activities (popularly known as galamsey)

Surface mining is the dominant method of mining used by small-scale mining artisans due to its cost effectiveness, low capital intensity and minimal technical skill requirement. Large scale mining, on the other hand, often employs the deep-pit method (Plate 1b), as it requires huge capital investment, sizable number of workers and sophisticated technology [5]. In addition, it usually needs government approval as licensing is required.

Plate 1b. Large-scale mining (deep/underground)

Before 1989, small-scale mining was considered illegal in Ghana and was highly unregulated. As part of the Economic Recovery Programme (ERP), however, the government attempted to modernize the sector and formalize it through the enactment of the Small Scale Gold Mining Law (PNDC Law 218). Despite this development, only a few small-scale mining artisans are registered [3]. Thus, majority of artisanal miners are unregistered and operate illegally, making monitoring of their activities and enforcement of mining regulations very difficult [11,16,24]. Even though the law requires individuals to register with the Minerals Commission so they can be assigned specific areas to operate, the bureaucratic nature of the registration process renders many of them frustrated [24].

Ghana has the potential to produce a variety of minerals including limestone, manganese, silica sand, kaolin, mica, stone, feldspar, quartz, chrome, salt, among others [18]. However, the main minerals produced by large-scale companies are gold, diamond, bauxite and manganese; while industrial minerals such as kaolin, limestone and silica sand are mainly produced by small-scale operators. Silver is produced as a by-product from gold mines, while aluminium is produced from imported alumna. There is also growing potential for commercial gas and oil exploitation, with announcements of significant discoveries of off-shore oil in June 2007, which commercial exploitation started in 2010. Gold, however, is by far the most important mineral currently being exploited in Ghana. It contributes more than 90% of the total value of minerals in the country and has attracted the largest number of large and small-scale operators [2,3,18]. Table 2 gives the breakdown of minerals revenue by major mineral types in millions of US Dollars.

Table 2. Major Minerals Revenue (Millions of US$) in Ghana

Year	Gold ($M)	Diamond ($M)	Bauxite ($M)	Manganese ($M)
2004	731.2	26.0	10.6	30.2
2005	903.9	34.7	18.0	39.0
2006	1327.5	30.0	22.6	39.9
2007	1711.5	26.4	19.7	36.8
2008	2202.9	18.9	19.8	62.3
2009	2842.8	7.0	11..2	64.9
2010	3620.8	11.1	15.1	77.8
2011	4630.2	14.9	13.4	120.0

Source: Chamber of Mines Annual Reports (2011).

Currently, there are about seventeen (17) large-scale mining companies and three hundred (300) registered small-scale mining groups involved in mining exploration in Ghana. The key players in the large-scale sector include AngloGold Ashanti Ltd, Goldfields Ghana Ltd., Golden Star Resources Ltd., Newmont Mining Corporation, Red Back Mining, Adamus Resources Ltd, Alcoa Inc., Alcan Aluminum Ltd, Ghana National Manganese Corporation, and the Ghana Consolidated Diamonds Ltd [5,10]. The Obuasi mine of Ashanti Goldfields Corporation (AGC), which started in 1890, is by far the largest and oldest operation in the country. It accounts for more than 50% of Ghana's total annual gold production. Other mines operated by the company in Ghana through its expansion programme include the Bibiani, Anyanfuri and Iduapriem mines [3].

Diamonds are mined from alluvial sources mainly from the Birim Diamond field at Akwatia and the Bonsa diamond field in the Eastern and Western regions respectively. Ghana Consolidated Diamonds Limited (GCD) undertakes large-scale diamond mining. However, this company has been on the divestiture list since 1993. Its share of the nation's diamond output has been dwindling, currently accounting for less than half of the total annual output [3]. Manganese, on the other hand, is mined at Nsuta, Western region, by Ghana Manganese Company Limited (GMC), while bauxite is mined at Awaso by Ghana Bauxite Company Limited (GBC). Table 3 gives the breakdown of major minerals production in Ghana for the period 2000-2011.

Table 3. Major Minerals Production in Ghana (2000-2011)

Year	Gold ('000' Ounces)	Diamond ('000' Carats)	Bauxite ('000' M/t)	Manganese ('000' M/t)
2000	2,315.0	627.0	503.8	638.9
2001	2,205.5	870.5	715.5	1,212.3
2002	2,115.2	924.6	647.2	1,132.0
2003	2,208.2	927.0	494.7	1,509.4
2004	1,794.5	911.8	498.1	1,593.8
2005	2,149.4	1,062.9	726.6	1,714.8
2006	2,244.7	970.8	885.8	1,658.7
2007	2,486.8	837.6	748.2	1,156.3
2008	2,586.0	598.0	694.0	1,089.0
2009	2,930.3	354.4	490.4	1,012.9
2010	2,970.1	308.7	512.2	1,194.1
2011	2,924.4	283.4	400.1	1,827.7

Source: Chamber of Mines Annual Reports (2011).

1.2. Evolving Policies and Institutions in the Ghanaian Mining Sector

The long tradition in the extractive sector has enabled Ghana to build an institutional framework and organizations to support the mining industry. The key organizations include the Ministry of Mines and Energy, the Minerals Commission, the Geological Survey Department, the Chamber of Mines, the Mines Department, the Environmental Protection Agency, Lands Commission, Land Valuation Board and the Forestry Commission. These organizations provide support to ensure optimal exploitation of the country's natural resources [3].

The Minerals and Mining Law of 1986 provides the overall legislative framework for mining in Ghana. This law established the royalty and corporate tax rates in this industry; but was however amended in 1994 and 2005 as Ghana transitioned into a constitutional rule. The amendments focused on revising the corporate tax and royalty rates and limiting the duration for mining lease. In addition, three new mining laws were implemented after the legalization of small-scale mining. They were the Small-Scale Gold Mining Law, the Mercury Law and the Precious Mineral Marketing Corporation Law. The Small-Scale Gold Mining Law covers the registration, licensing and the establishment of support centres for small-scale mining. The Mercury Law legalizes the purchase of mercury for mining purposes, while the Precious Minerals Marketing Corporation Law provides official marketing services for small-scale gold and diamond miners and promotes trade in precious metals, diamond, and jewellery in and outside Ghana [10,11,16,25,27].

The two main institutions with direct supervisory and oversight responsibilities over the mining sector in Ghana are the Ministry of Lands and Natural Resources and the Mineral Commission. The Ministry of Lands and Natural Resources is responsible for all aspects of mineral resource exploration in Ghana. It formulates policies and grants licenses for mining and mineral exploration. The Mineral Commission, established under Article 269 of the 1992 Constitution of Ghana and the Minerals Commission Act of 1986, is the principal institution for providing regulatory framework for mining in the country. It administers the Mining Act, making mineral policy

recommendations, promoting mineral developments in the country and advising government on mineral related issues. It also ensures compliance with the mining and mineral law and regulation. It operates under the purview of the Ministry of Mines [24].

These institutions are also supported by agencies such as the Environmental Protection Agency, the Geological Survey Department, the Mines Department, the Lands Commission, and the Chamber of Mines. The Environmental Protection Agency (EPA), established under the Environmental Protection Agency Act of 1994, is responsible for all environmental issues in the country. This agency formulates and implements environmental policies and enforces compliance with environmental laws and regulations. The Mining Section of EPA provides direct oversight on the mining industry with key responsibilities such as processing environmental permits and certificates; monitoring of mining activities; environmental assessments; investigating complaints relating to mining activities; and creating environmental impact awareness. The Geological Survey Department provides geological study support to the government and the mining industry. The Mines Department has the oversight responsibility for ensuring compliance to health and safety inspections standards by mining companies. The Lands Commission provides legal records of issued mining licences and examination of all new applications. The Chamber of Mines is an association of mining companies and has the responsibility of addressing immediate concerns of all stakeholders within its jurisdiction [11,24,25].

1.3. Environmental Impacts of Mining Activities in Ghana

Despite all these policies and institutions, environmental degradation in most of mining communities in Ghana is still of a major threat and concern. The extent of environmental devastation caused by mineral mining in Ghana is well documented [7,8,9,11,25,26,31,32]. Nevertheless, the magnitude of damage caused largely depends on the mining method being used [11]. This has become increasingly alarming, raising serious concerns among key stakeholders. Low entry barriers; improper research methods; lack of coordination among regulatory bodies; poor mercury management; inadequate personnel and resources [25,34]; inadequate research; ineffective community participation; cumbersome and lengthy processes in registering small-scale mines; and lack of environmental education and awareness creation have been found as contributory factors to the persistent environmental devastation caused by mining in Ghana.

In Prestea, one of the mining communities in Ghana, increased mining activities have resulted in disproportionate contamination of major water bodies leading to loss of aquatic organisms, destruction of the biodiversity, removal of vegetation, depletion of soil resources and loss of farmland. For instance, a study by [37] in Prestea, found high levels of arsenic and antimony concentrations in the rivers ranging from 0.90 – 8.25 ppm and 0.09 – 0.75 ppm respectively, far exceeding the World Health Organizations recommended values of 0.01 and 0.005 ppm respectively. Again, [38] reported a spillage caused by BGL (Bilington Bogoso Gold now called Golden Star Resources Bogoso/Prestea Limited) on 23 October 2004, a major surface mining company found in the area. This spillage, according to [38], emanated from the new tailings dam of the company into the River Aprepre, which flows into other rivers, including Egya Nsiah, Bemanyah, Manse and Ankobra. They indicated that the cyanide spillage affected Dumasi and other towns, including Goloto, Juaben and Egyabroni and that some residents of Dumasi and other villages in this area picked up and ate dead fish, crabs, shrimps and other aquatic organisms that were found floating on the surface of the river.

It is against this background that this paper assesses the environmental impacts of mining activities in mining communities in Ghana with particular reference to the current situation at Prestea. The results of this study will therefore raise concern of the current environmental degradation situation at Prestea and prompt and inform policy makers in finding solutions to the current environmental problems in the area.

2. Methodology

The study was carried out in the mining communities in Prestea, one of the small towns in the Prestea Huni-Valley District, Western Region of Ghana. Prestea is located at 5.43274 latitude and 2.14284 longitudes at an elevation/altitude of meters. The average elevation of Prestea is 59 meters. It lies about 50 km north of the Coast of the Atlantic Ocean and on the west bank of the Ankobra River, about 60 mi (100 km) northwest of Cape Coast. A railway line used to connect with Prestea to Tarkwa and beyond to the coastal city of Sekondi-Takoradi. The District is located in the Rain Forest zone of Ghana and enjoys a wet equatorial climate. It has two rainfall patterns usually from March to July (major season) and from September to November (minor season) [20]. The District experiences high rainfall with a mean annual rainfall of 187.83mm. Temperatures are high all year round with significant daily and seasonal variations. The annual average temperatures range between 26 ^{o}C and 30°C. Humidity varies from 75-80 percent in the wet season and 70-80 percent in the dry season [20]. The soil is deep, open and acidic in many places due to heavy leaching of base from the top soil because of high rainfall, humidity and temperatures. The acidity of the soil reduces the availability of Phosphorus, Calcium and Magnesium in the area [20].

The population of the people in this area is about 35,760 and it is the 46th most populous town in Ghana. Major socio-economic or livelihood activities in the area include farming, petty trading, teaching and gold mining (large scale and small scale). The three main large scale mining companies in this area are Golden Star Resources, Prestea Sankofa Gold Limited and African Explosive Limited. Majority of the people are engaged in petty trading which includes selling food stuffs, stationery, confectionery and clothing. The private informal sector is the largest employer in the District, employing 89.1 percent of the population followed by the private formal with 7.5 percent [20].

Crops grown in the area are subsistence and cash crops. Subsistence farming in the area comprises vegetable growing such as okra, tomatoes and pepper; cereals such as maize; and cultivation of root and stem tuber crops such as cassava, cocoyam and *colocasia*. Cash crop farming mainly comprises cultivation of oil palm and cocoa. The vegetables, cereals and root and stem tuber crops are mainly kept to feed the family and surplus sold to supplement the family's income. The cash crops are mainly grown for sale as major source of livelihood. In the rural localities, almost 100 percent of the households (97.9%) are agricultural households. Poultry (chicken - 66.4%) is the dominant animal reared in the District [20]. Map of the study area is given in Figure 1 below.

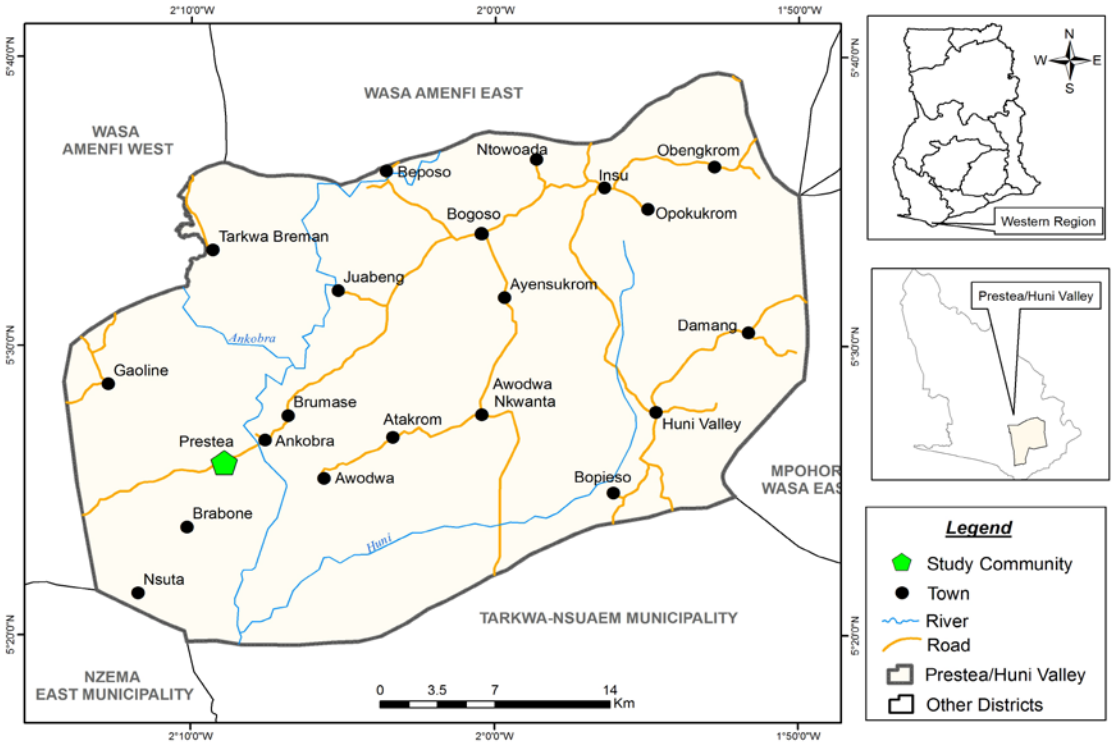

Figure 1. Map of the Prestea Huni-Valley District showing study community, Prestea. Source: Cartography Unit, Department of Geography and Regional Planning, University of Cape Coast, Ghana. 2015

2.1. Sampling Design and Data Collection

This study employed a purely qualitative field survey research approach, where data was collected majorly through qualitative techniques during the fieldwork that took place in the study area between May and August 2014. Data sources included both primary and secondary data. Primary data was gathered through key tools such as participant observation using an observation guide, in-depth interviews using a checklist of questions, and environmental assessments of various mining sites in Prestea. A random sampling technique was adopted for the selection of the communities and/or respondents for the interviews. Communities such as Bondaye, Himan, Ankobra, Asoampa, Bola Ekyir, Ash Town, Nankaba, Dagaatse Compound and Anfegya were selected for the survey. The secondary data used in this study included a critical review of literature on environmental impacts of mining in Ghana, 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.

3. 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.

3.1. Impacts

3.1.1. Impacts on Water Quality

Results from the field observations in the study area revealed that major rivers in the area such as Ankobra and Asesree, which used to serve as the main sources of water for domestic purpose in the surrounding townships, had been heavily polluted by mining activities (Plate 2 and Plate 3), especially those of illegal small-scale mining (popularly known as 'galamsey'). Mining, especially surface mining results in adverse environmental impacts on water bodies (rivers and streams) in Ghana through a release of effluents such as mercury, arsenic and solid suspensions [11,15,24,25,39]. Moreover, [30] discovered that between 1994 and 2001, five major cyanide spillages and leakages occurred resulting in contaminating some major rivers in Ghana. He indicated that cyanide spills and leakages by mining companies such as Teberebie Goldfields Ltd and Ashanti Goldfield Company Ltd (now AngloGold Ashanti) resulted in polluting the Anikoko,

Angonabe, Bodwire and Assaman rivers, all in the western region of Ghana. This led to a significant loss of aquatic organisms, displacement of people, and a depletion of livelihood and drinking water for some communities.

Plate 2. Pollution of River Ankobra due to mining activities in Prestea. Source: Fieldwork, June (2014)

Plate 3. Pollution of River 'Asesree' due to mining activities in Prestea. Source: Fieldwork, June (2014)

Also, it was found out 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 (Plate 4). This agrees with the findings by [25], 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. [12] pointed out that Mercury is used extensively in the process of mining as it is added to the refined concentrate to form a gold amalgam, which is then heated to separate the gold. Another study by [15] in the Dumasi Township in the western region of Ghana also confirmed high mercury contamination with large concentrations in groundwater, river sediments and fish.

Plate 4. Illegal small-scale mining activities on-going at Prestea. Source: Field Survey, June (2014)

Interviews with some residents in Prestea during the field survey revealed that they are spending huge sums of money to access and treat groundwater (Plate 5) for their domestic use such as drinking, cooking, washing and bathing. Consequently, the government had embarked on digging boreholes for some communities to access water for their domestic use. Residents in Prestea have therefore resorted to use of groundwater. One respondent in an interview revealed that they drill as deep as 80m underground just to reach water that is free from contaminations. He further added that they incur a cost of as much as 12,000 Ghana Cedis (equivalent of 3,500 USD) in drilling, laying pipes to tap the groundwater as well as putting up the POLYTANK for water storage and supply. This is because most of the rivers (surface water sources) have been heavily polluted and their water rendered unsafe for domestic use due to mining activities in the area. Similar findings were also obtained by [39], who in their study, found high levels of arsenic contamination in drinking water from streams, shallow wells and boreholes in Obuasi, in the Ashanti region of Ghana, ranging from 2 to 175μgl^{-1}. This was attributed to two factors: mine pollution and natural oxidation of sulphide minerals predominantly arsenopyrite (FeS_2).

Plate 5. A borehole for groundwater exploitation in Prestea. Source: Fieldwork, June (2014)

3.1.2. Impacts on Ecosystem/Loss of Vegetation

Concerning impacts on the ecosystem, the study found out that greater proportion of the land area have been rendered bare due to mining activities. Large tracts of land in many areas such as Nankaba, Asoampa, Ashtown, Bondaye, Ankobra, Anfegya, 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. According to [3], the land has lost viability for agricultural purposes, as well as loss of habitat for birds and other animals, in addition to erosion. This has culminated in the destruction of the luxuriant vegetation, biodiversity, cultural sites and water bodies. [25] also adds that small-scale gold mining has been responsible for the removal of vast quantities of surface vegetation and mass deforestation in Ghana. In addition, miners typically abandon pits and trenches without properly reclaiming spoils. [32] further states that substrates, usually called the overburden or mine spoil, are often the characteristic of all gold mined lands in Ghana.

Plate 6 shows land devoid of vegetation cover with massive erosion occurring in one abandoned mined site at Prestea. The erosion has resulted in the removal of soil nutrients, causing siltation, turbidity and eutrophication of the nearby rivers; thus leading to reduction of land productivity, reduced water quality, and reduced biodiversity, among others. A further interview with one former underground mining engineer in Prestea revealed that this area was a major river source that has dried up as a result of vegetation removal and washing of sediments into the river from illegal mining activities. This further confirms the finding by [32], that many areas disturbed by mining in Ghana are highly susceptible to erosion due to lack of existing vegetation, the presence of fine, dispersed particles and steep slopes, and forming huge gullies and pits.

Plate 6. Degraded land devoid of vegetation cover resulting from gold mining activities in Prestea. Source: Fieldwork, June (2014)

Furthermore, the method of surface mining used by mostly registered large-scale, small-scale and unregistered artisans often results in the excessive destruction of productive land, deforestation and mass trenching. [11] add that productive arable lands have been left bare without any form of protection thereby increasing the runoff and causing turbidity (Plate 7). According to [29], the exploitation of mineral resources often leads to extensive soil degradation through the destruction of vegetation and alteration of microbial communities, resulting in low soil fertility and productivity. The Food and Agriculture Organization estimated that between 1990 and 2005, gold mining activities in Ghana contributed significantly to land degradation and loss of cultivable land, resulting in a massive loss of forest cover (26%) and arable lands (15-20%) at the Tarkwa, Ayanfuri, Dunkwa, Esaase and Bogoso mining areas in Ghana [13].

Plate 7. Massive water runoff and subsequent soil erosion on an abandoned gold mining area in Prestea. Source: Fieldwork, June (2014)

A study conducted by [35] to assess the impact of small-scale mining on land in the Western part of Ghana revealed that mining removes vegetation and topsoil, and often results in inevitable loss of farmland permanently. They further reported that surface mining alone accounted for about 58% of the region's deforestation, 45% loss of farmland (within mining concessions) and pervasive spillover effects often resulting from expansion of mining activities into reserved forests.

Plate 8. Impacts of land degradation due to illegal small-scale mining activities in Prestea. Source: Fieldwork, June (2014)

Plate 9. An underground mining operation by illegal small-scale miners in Prestea. Source: Fieldwork, June (2014)

Plate 10. Huge patches of forest cleared to establish resting grounds for miners in Prestea. Source: Fieldwork, June (2014)

3.1.3. 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 Ghana have been cleared to accommodate surface mining activities. It was observed during this study that the gold-mining operations have caused a disproportionate amount of damage to the lands in these areas (Plate 8). 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 (Plate 9). This underground pit, where miners enter to go search for gold is usually called *'ghetto'*. Furthermore, huge patches of forest have been cleared in certain areas to establish resting grounds for miners (Plate 10). Such practices had also played a major role in altering the local hydrological patterns in Prestea.

[3] reported that surface mining concessions have taken over 70% of the total land area of Tarkwa, a mining community in western region of Ghana. They further estimated that at the close of mining, a company would use 40 – 60% of its total concession space for activities such as siting of mines, heap leach facilities, tailings dump and open pits, mine camps, roads, and resettlement for displaced communities, which, according to the authors has significant adverse impact on the land and vegetation, which are the main sources of livelihood for the local people. In addition, these authors also reported that the tailings dam of one mine has taken a total of 6.3 Ha of land. Given an estimated per acre yield of cassava of 108,000 bags in a year, this means the tailings dam has denied the farmer a minimum of 275,351 bags of cassava per annum. The tailings dam, plant site and feed stockpile of Ghana Australia Goldfields Ltd. alone will affect a total of about 315 farmers currently cultivating around the area. This has significant implications for the farmers' incomes and their food security [3].

Surface mining method by small-scale artisans often results in the removal of large quantities of topsoil, leaving the land bare and susceptible to erosion. The removal of the topsoil often renders the land practically incapable of supporting crop farming [23,24]. For example, a World Bank report on Ghana has indicated that, by the end of 1995 the total hectares of the land destroyed through small-scale mining activities were approximately 150,000 Ha. Other noteworthy environmental impacts from small-scale gold mining, *inter alia*, included acid mine drainage (on a micro scale), cyanide contamination (in certain districts), siltation, river dredging and alteration, and erosion [25].

Furthermore, abandoned mining pits by both large and small-scale miners without proper reclamation also lead to further degradation of the landscape [11,25]. Mined pits left unfilled renders land unsuitable for any other purpose and become repositories for water resulting in breeding grounds for malaria-infected mosquitoes that pose significant threat to both humans and animals [1,11,28,33]. Obuasi, one of the major mining towns in Ghana, has been described as a 'hanging town'. This is because, aside from the surface mining surge in the area, the town is also well noted for underground mining. The underground method of mining often requires the use of heavy explosives to breakdown the rocks, resulting in severe damage to the landscape and exposing the environment to pollutants such as chemicals, dust, and fumes [11].

3.1.4. Impacts on Soil Quality

Another area where mining has a devastating effect on the environment in Ghana is the soil. Many research findings indicate that soils are adversely affected by surface mining [32]. Since mining here uses 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 [32].

Nearly all mine substrates have very low levels of macro-nutrients (especially nitrogen (N), phosphorus (P) and potassium (K)). [23] argued that regardless of the overburden type used, plant available N and P tend to be low on mined soils, which may limit tree growth. [36] also added that the consequences of physical disturbance to the topsoil during stripping, stockpiling and reinstatement, cause unusually large nitrogen transformations and movements with eventually substantial loss of soil fertility and productivity. Low pH is a particularly intransigent problem in wastes that contain iron pyrites, which, on weathering, will generate sulphuric acid and (if there is no acidic neutralizing capacity in the waste) induce pH values of <2.0. Other problems include toxicity, especially of aluminium, zinc and other metals in acidic wastes, and

these can significantly affect plant growth [32]. For instance, [12] reported that pH levels in soils in Prestea/Bogoso in the western region of Ghana are as low as 3.96. It has commonly been noted that low pH is a characteristic of all gold mined substrates in Ghana [32].

In addition, mining removes the vegetation and inevitably leads to the loss of some plant nutrients from the site [6]. [12] found soil organic carbon (SOC) content of Golden Star Resources Prestea/Bogoso mined area at 0.14 %, which is below the accepted level of SOC of soil fertility, giving an indication of disruption of ecosystem functioning and loss of litter layer due to mineral mining. According to [21], organic matter values are considered low if less than 4%, medium from 4% to 8%, and high if above 8%. Another similar study by [12] found lower and reduced content of soil nitrogen (N) and phosphorus (P) when compared to the natural forest, due to the same reason of ecosystem disruption, removal of vegetation and loss of litter layer during mineral mining.

Moreover, the mining process scrapes the topsoil with bulldozers and other heavy machinery and the soils are taken to the laboratory for the purpose of extracting mineral [32]. [17] also indicated that as topsoil is only about 20 cm deep, and contains most of the plants' available nutrients, the scraping action with bulldozers and other heavy machinery depletes the soils of the fertility and productivity, exposing the subsoil, which are unsuitable for crop production.

Furthermore, stockpiling of top soil in mounds, which is a very common phenomenon during mineral extraction has been shown to affect the biological, chemical and physical properties of the soil. According to [6], stockpiling reduces the quality of the soil resources. Also, stockpiles become anaerobic, other plant propagules die and populations of useful soil micro-organisms are reduced significantly. Plate 11 shows mined soil stockpiled in one of the mining sites in Prestea. Stockpiling has been found to decrease soil aerobic and anaerobic organisms. The process of stockpiling also generates heat that kills some soil beneficial organisms that cannot survive such high temperatures.

Plate 11. Mined soil stockpiled in one of the mining sites in Prestea, Ghana. Source: Fieldwork, June (2014)

3.2. Some Contributory Factors to the Persistent Environmental Degradation Problems in Ghana

Here, we discuss briefly some contributory factors underpinning the persistent environmental degradation problems in mining communities in Ghana, with particular reference to the situation at Prestea. Some common identified factors such as ineffective community participation, cumbersome and lengthy processes in registering small-scale mines, weaknesses in the mining environmental policies and enforcement, among others are discussed.

3.2.1. Cumbersome Process of Registering Small Scale Mines

A field interview with one small-scale mining expert in Prestea during the study revealed that the process of registering small scale mining is such a cumbersome one that deters many who will like to register from doing so. This agrees with [9], who found out that in 12 mining communities around the Tarkwa municipality of Ghana who are involved in illegal mining, these illegal miners complained that the process for acquiring licenses is rather cumbersome, long and frustrating. Previously, the process took only a month because the license acquisition process was localized. Recently, however, the process has taken as long as two years [9].

3.2.2. Ineffective/Inadequate Community Participation in Environmental Governance

A documentary by Journalists for Human Rights and Africa University College of Communications in Ghana on mining activities in Prestea revealed that effective community participation in corporate environmental governance remains a major challenge in Prestea. Again, an interview with one resident also revealed that Golden Star Prestea/Bogoso Resources, a major mining company in the area had no respect for the community members in corporate environmental governance. He had this to say:

"*When the surface mining came in…they brought in with this public hearing. They promised heaven and earth, but after they have started their operation we saw that they have destroyed most of our streams, and spring waters, because we were having so many spring waters around us. The company just destroyed the farms and the water bodies around here. The company does not treat the community members as human beings*".

In the same interview, the chief of the area also said:

"*EPA should not act like a toothless bull-dog; they should act by the mandates given them. For me, I will say the EPA is sleeping with the mining companies.*"

Similar research findings by [9] found that community members in this area have not participated in mineral resource governance, which situation, they added could potentially stimulate conflict between communities and civil society on one hand, and the corporations and government on the other hand. Also, the same study found that the corporations did not involve the host communities in determining the actual social priorities of host communities. This led to misplaced priorities as far as corporate social responsibilities are concerned. The study found that a number of the projects undertaken by the mining companies as part of Corporate Social Responsibility (CSR) were either not functioning due to inadequacy of the affected communities' involvement in decision making.

3.2.3. Weaknesses in the Mining Environmental Policies and Enforcement

A study by [9] on the assessment of legal framework for corporate environmental behaviour and perceptions of residents in mining communities in Ghana found a number of weaknesses in the mineral and mining environmental policies. These included, but not limited to the following: no best practice management systems for applying Corporate Social Responsibilities (CSR) nor are there nationally recognized CSR standards against which a company can benchmark its efforts; weak institutions; lack of transparency in the legal and regulatory framework in terms of valuation and payment of compensation and royalties; non-involvement of the communities in the valuation of the crops on their farms; unsound environmental management systems; no standards for blasting in host communities in the mining industry regulatory framework as of May, 2009; among others.

4. 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 mining in Prestea in western region of Ghana. The paper concludes using the SWOT analysis by outlining the strengths, weaknesses, opportunities, and threats of the mining in the study area.

4.1. Strengths

Mining has significant benefits to the mining communities in Ghana 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.

Even though there has been poor management of mercury in the process of extraction, but extensive use of the chemical in mining is necessary since it is added to the refined concentrate to form a gold amalgam, which is then heated to separate the gold. This can be viewed as strength of the process.

4.2. Weaknesses

Among the weaknesses include the methods of mining employed in the area. Surface 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.

4.3. Opportunities

There is a great opportunity to improve and enhance the cumbersome and lengthy processes in registering small-scale mines. This stands to regularise 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.

4.4. Threats

Mining activities have posed significant threats to major rivers in the western region of the country which hitherto served as sources of water for domestic and other purposes. Many of these rivers 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.

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.

5. Recommendations to Minimize Environmental Impacts of Mining in Ghana

Upon a detailed analysis of the current situation of mining in Prestea in the Prestea Huni-Valley District in Ghana, the study came up with the following recommendations to minimize environmental impacts associated with mining in Ghana. The recommendations mainly focused on the current situation in Prestea Huni-Valley District.

5.1. 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 [14]. 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" [41]. 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 EIA process, reduce conflicts associated with mining projects between mining companies and the affected communities, and help in effective environmental decision makingand thereby ensures the sustainability of mining activities.

5.2. Easing the Registration Process for Small Scale Mines

The government should remove the unnecessarily difficult, frustrating, lengthy, and bureaucratically cumbersome registration regulations and policies for illegal small-scale miners to encourage more people to register and obtain licenses, thereby reducing the higher rates of environmental degradation associated with illegal mining. Again, since unregistered small-scale artisans are driven solely by livelihood and survival motives, they pay little respect to issues of environmental sustainability. As such, consideration for future generations with respect to adhering to strict environmental regulations is secondary to them.

The Ghanaian government continues to put into practice procedurally difficult and bureaucratically cumbersome regulations and policies for small-scale miners, which have the effect of favouring the interests of established large-scale miners. Such cumbersome, lengthy and frustrating process in registration of legal small scale is a disincentive for illegal small-scale miners to register and obtain licenses and therefore results in proliferation of illegal mining with consequent degradation of environmental quality in many mining communities in Ghana.

5.3. 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 behaviour. 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 ensure that human activities on the environment do not have harmful effects on humans and the physical environment.

5.4. 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.

5.5. 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 Ghana.

Statement of Competing Interests

The contents of this paper are a product of research done jointly and severally by the above authors. This paper has not been published elsewhere, and the authors take responsibility jointly and severally over the

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