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THE ENVIRONMENTAL AND HEALTH IMPLICATIONS OF ARTISANAL SMALL GOLD MINING IN KADEMA, UPPER EAST REGION, GHANA

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ANURU-YENG DORCAS AKANLUGWAI

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THESIS SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAND RESOURCE STUDIES,

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DECLARATION

I submit this work towards the partial fulfillment for the awarding of M.Phil. Degree in Environment and Resource Management by the University for Development Studies (UDS), Wa-Campus. I affirm that, this is my individual work and to the greatest of my knowledge it has not been submitted by anyone, person or institution for the honor of MPhil Degree. All due salutations have been made to all sources referred in the processes of the study.

Signature……………………………………………..

ANURU-YENG DORCAS AKANLUGWAI

Student

Date…………………………………………………….

I hereby pronounce that the groundwork and production of the thesis were oversaw in accordance with the procedures on supervision of dissertation laid down by the University for Development Studies and that the laid down guidelines were strictly followed.

Signature……………………………………………..

PROF. OSUMANU KANTON

Principal Supervisor

Date……………………………………………………..

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DEDICATION

I dedicate this academic piece to my supervisor, Prof. Osumanu Kanton, my Parents, Mr. & Mrs. Joseph Yarrow Abuntuik and Siblings.

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ABSTRACT

Mining is seen as a key profitable accomplishment which has the latent of contributing to the growth of economies. At the same time, the environmental and health implications of mining on communities have been a major concern in recent times. This study examined the environmental and health implications of artisanal gold mining (ASGM) in Kadema in the Builsa North District in the Upper East Region. Two communities within the district were covered for the data required for the study. These communities in the district were purposively chosen because of the fact that they are the communities where ASGM is taking place, which are Bachonsa and Chansa. Purposive sampling was used to select officials from the district assembly and health centres in the two communities as well as Households .The main objective was to produce a sample that was logically assumed to be representative of the population. On the other hand, accidental sampling was used to select the artisanal miners. The sample was haphazardly gathered by interviewing the first people the researcher runned into in the mining community who were of the sound mind and willing to talk. The main instruments for primary data collection were questionnaires, interview schedules and in-depth interview guides. A total of 160 respondents were interviewed for data. Quantitative methods as well as additional qualitative methods were employed to analyse the data collected. The study revealed that ASGM undertakings have given rise to land degradation leading to inadequate land for local food production and other purposes. There is pollution, which has affected mainly water resources, with major dam being the only source of water becoming unsafe for drinking and other domestic uses. Air and noise pollution are also apparent in the area. The collective effects of environmental problems have translated into health

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problems with high incidence of ailments such as malaria, typhoid, cholera, respiratory tract infections and skin diseases as compared to previous records from the health facility. Uncovered mined pits have become breeding places for mosquitoes and the constant grinding of soils and stones usually produce dust and noise where some respondents testified that they have become asthma patients because of the dust they have been inhaling during the grinding process. The Builsa North District Assembly should establish environmentally responsible mining practices trainings and follow-ups made to check the mining practices. Also, the District Assembly as well as private individuals should educate artisanal gold miners on sustainable mining methods and provision of alternative livelihood programs (ALP).

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LIST OF ACRONYMS

AGM	Artisanal Gold Mining
ASSGM	Artisanal Small Scale Gold Mining
ASM	Artisanal Mining
SSM	Small Scale Mining
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
BG	Bare Ground
NGO	Non-Governmental Organization
DGTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
ERP	Economic Recovery Policies
GFRA	Global Forest Resource Assessment
ILO	International Labor Organization
CASM	Communities Artisanal and Small-Scale Mining
SSUM	Small Scale Underground Mining
UNIDO	United National Industrial Development Organization
US-FDA	United Nations food and drugs Authority
EPA	Environmental Protection Agency
WHO	World Health Organization
FeAsS	Iron Arsenic Sulphide
Pbs	Lead sulphide
Hg	Mercury
Pb	Lead
As	Arsenic
STIs	World Health Assembly
ALP	Alternative Livelihood Project
LEDP	Local Economic Development Projects
SPSS	Statistical Package for Social Science
CSIR	Council for Scientific and Industrial Research
WRI	Water Research Institute

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GSS	Ghana Statistical Service
BGL	Bogoso Gold Limited
MMSD	Mining Mineral and Sustainable Development
UN	United Nations
ITDG	Intermediate Technology Development Group
SSGML	Small Scale Gold Mining Law
GMMA	Ghana Mineral and Mining Act
ZMC	Zenon Mining and Mineral Act
MDG	Millennium Development Goal
DFID	Department for International Development
AL	Alternative Livelihood
LI	Legislative Instrument

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CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the developing world, a combined 30 million individuals extract more than 30 different minerals using rudimentary techniques. Gold is the preferred mineral extracted by artisanal operators due to its high unit value and its market price, which has increased almost sevenfold over the last decade. Between 10 and 15 million people are directly involved in this activity, producing 300e 400 tonnes of gold annually. This production, however, has caused numerous environmental problems, including high levels of river siltation and mercury pollution (UNEP, 2008). Artisanal gold mining (AGM) is herein defined as "operations, independently of the size, that use rudimentary techniques to prospect, mine and process gold ore" (Veiga, 1997). Globally, Artisanal and small scale-gold mining involves an estimated 10-15 million miners including 4.5 million women and 1 million children (UNIDO, 2006; Buxton, 2013). According to a report (Tschakert and Singha, 2007), roughly 85% of the total labor force operates without an official license. Hilson and Potter (2003) estimated that half of those employed in the sector are women, one of the highest rates in Africa. Reports revealed that though they (children) may not necessarily be involved in gold digging, children as young as 10 years old crush, wash, mill, haul and process ore (Armah et al., 2013: Tschakert and Singha, 2007). The international mining industry is increasingly regulated and required to implement stringent procedures to prevent or mitigate its environmental impacts (Jones and Salmon, 2012). In contrast, Poverty, high commodity prices, low agricultural output and poor governance have attracted many people in developing countries to the largely unregulated artisanal gold mining (ASGM). Currently ASGM activity is documented in more than 70 countries and

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provides direct employment to at least 15 million people and indirect employment to more than 100 million people around the world (WHO, 2013).

The 2012 "Investing in Africa Mining Indaba", however, revealed a greater urgency among both government and corporate delegates to address ASM mining.ASM activities in Africa engage about 8 million workers, who in turn support about 45 million dependents. Moreover, the number of ASM miners is growing as a result of rising commodity prices and limited economic opportunities in other sectors. According to the World Bank, small scale mining is widespread in developing countries in Africa, Asia, Oceania, and Central and South America (World Bank, 2013).

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However, the government of Ghana under the auspices of a German Non-Governmental Organization (NGO), Gesellschaft Technishe Zusannebarbeit (GTZ), and the World Bank has undertaken a number of initiatives to formalize and regularize resident SSM operations (Hilson, 2001). In Ghana, SSM has been carried out for hundreds of years. It is currently and widely operated in the country by both licensed operators and unlicensed miners popularly known as galamsey operators. According to the Ministry of Lands, Forestry and Mines of Ghana, the number of artisanal miners increased rapidly by 941.73% from 1984 to 2004 following the promulgation of the Small Scale Gold Mining Law, PNDC Law 218 of 1989. The legalization was to revive the SSM sub-sector, facilitate supervision and minimize associated environmental hazards. Although the efforts by government and the NGOs have noticeably improved the efficiency of operations, certain serious concerns continue to be largely ignored by the miners, the Minerals Commission and government, and have increasingly become unmanageable. Ground failures resulting from weak unsupported or poorly supported stopes have led to fatalities and various

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degrees of injuries in recent times. Dust and fumes generated from chiseling, drilling, blasting, grinding and crushing of ore are potential health threats. Most of the stopes worked in by the miners are accessed by adits without adequate ventilation systems in place, leading to the accumulation of dust and fumes in the underground workings. Health hazards related to dust and fumes are well documented in the literature (Dockery et al., 1989; Bascom et al., 1996; Gielen, Van Der Zee, Van Wijnen, Van Steen, & Brunekreef, 1997; Pope, Hill, & Villegas, 1999; Yu, Sheppard, Lumley, Koenig, & Shapiro, 2000; Dockery, 2001; Gan, Man, Senthilselvan, & Sin, 2004; Gauderman et al., 2004; Jansen et al., 2005; Colucci, Veronesi, Roveda, Marangio, & Sansebastiano, 2005; Bansah & Amegbey, 2012). Even though, ASGM in Ghana is by law limited to only Ghanaians, the last decade has seen a large increase in involvement by foreign nationals, mostly Chinese miners and migrants from neighboring Togo, Burkina Faso and Ivory Coast and others from western and non-western cultures. The small scale mining activities of these foreign nationals have involved the destruction of cocoa farms, wide areas of land and protected forests, and reported as security threat to the people of Ghana (Al-Hassan & Amoako, 2014). In 2013, an inter-ministerial taskforce (drawn from the military, immigration and police) was set up by the president of Ghana to crackdown on these illegal miners. During that year, the Ghanaian authorities arrested and deported over 4500 illegal Chinese miners (The Guardian, 2013). The Chinese foreign minister visited Ghana in 2014, and pledged Beijing's support to help tackle the illegal small scale mining issue (Agence France-Presse, 2014). Although government's interventions have reduced the scale of illegal mining activities by foreign nationals, there are still some foreign nationals operating in remote mining areas (e.g. Manso Nkran) of the country. The influx of migrant miners has led to a higher level of mechanization of the operations

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(use of excavators, trucks, dredging machines, crushers,etc.) and has increased the scale of mining. Consequently, this has increased the levels of land degradation, rechanneling of river/stream courses, and contamination of surface water bodies in terms of increased turbidity, total suspended solids (TSS), and total dissolved solids (TDS) to unacceptable levels. Bansah and Bekui (2015) report unacceptably high turbidity levels of water samples from the Bonsa River in the Western Region of Ghana, and attributed the levels to pronounced mining activities in and around the river. Small scale mining (both surface and underground) is practiced in Ghana and is also reported to occur in South Africa, China, Zambia, Congo, Rwanda Philippines, and India (Bugnosen, 2001; CIFOR, 2012; Chakravorty, 2001; Gunson & Yue, 2001; Hentschel et al., 2003; Kambani, 2003). In general, ASGM has the potential to be associated with a wide range of environmental and social challenges given the nature of the work and the conditions of poverty, which often result in the people turning to ASM in the first place (IIED, 2013; Hilson and Hilson, 2015; UNEP, 2012; UNECA, 2002; AMDC, 2014). The miners tend to lack access to basic infrastructure such as housing, sanitation and health facilities, and have to face various challenges, including securing legal recognition of land rights and access to credit and technical information and services.

Studies in the Talensi and -Nabdam Districts of Ghana have, however, witnessed higher number of migrants, both locals and foreigners, especially in the mining communities of recent times. They put up temporal structures as place of residence and are usually drifted towards the mine sites. Population increase exerts pressure on dwindling vegetation cover and it also leads to increase in settlement and bare areas. Settlement increased from 4.9% to 14.11% (1991- 2014). The instance of loss of vegetation in mining areas is not new. In comparison with other studies in Brazil,

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Venezuela, Tanzania and Zimbabwe, there has been evidence to prove that mining activities has a considerable effect on loss of vegetation (Laari, 2015). These reductions in Savannah vegetation can also be attributed to population increase in his study area. Environmental degradation has reduced the capacity of the ecosystem to meet the future needs of people for food and other products, and to protect them from flood and drought hazards. According to Laari (2015), a study in Wa East District of Ghana, areas around mining activities are becoming degraded of their vegetation and exposing more of the bare ground (BG) sites.

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1.2 Problem Statement

The legalization of small scale mining in Ghana has led to the proliferations and widespread mining activities with increased pressure on the environment and the ecosystem. Artisanal miners with or without technology could only extract gold in its simplest form (not in its compound form or rock). This is why in Ghana; the activities of small scale miners are usually at the river beds or along the river. With the traditional method which includes sluicing, it yields a recovery rate of approximately 60%. They can only obtain some fractions of gold from the ore while the rest is washed away into the nearest water body (Aryee et al., 2002). Agricultural farm lands are largely destroyed through mining thereby reducing the availability of farm land, reducing agricultural activities and consequently increasing shortages of food and other agricultural produce (United Nations Industrial Development Organization [UNIDO], 2006: Tschakert and Singha, 2007).

A 2010 Report by the Global Forest Resource Assessment (GFRA) has it that between 1990 and 2010, deforestation in Ghana is assumed to be at an annual rate of

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135 394.86 ha. As observed by Schueler et al. (2011), Surface mining in Ghana has resulted in deforestation (58%), and a substantial loss of farmland (45%) within mining concessions. Due to an increase in the activities of the artisanal mining, large forest reserved areas and agricultural farmlands are at the moment cleared and dug by the miners in search of minerals. This has led to loss of precious flora and fauna that give the people a local sense of place. Deforestation in the communities via mining activities is responsible for the shortage of food and herbs for local treatment of diseases and also resulted in the loss of top soil through wind, increased water erosion and exposed the lives of living organisms to both internal and external threats (Tom-Dery et al., 2012). Gold processing releases toxic substances such as mercury from amalgamation process, and several pollutants are discharged from abandoned mines direct to the environment. It is well known that these chemicals, in sufficient quantities, pose a serious threat to human health and is deleterious to a wide-range of ecological entities through eco-toxicological effects (Obiri et al, 2006). Artisans without any form of protective cloths, carry bags of mud on their heads or backs to sieving and washing sites. This air is inhaled by the miners having little or no knowledge of the health hazards they are being exposed to. Clinical studies have shown that increasing exposure to mercury could cause health challenges such as; kidney pain, respiratory problems, neurological damage, dizziness, gingivitis, muscular tremors and psycho-pathological symptoms such as depression and exaggerated emotional responses, which can be mistaken for alcoholism, fever, or malaria; dysfunction of kidneys, memory loss, miscarriages, vomiting, and potentially death, (Tschakert and Singha, 2007). In general, ASM has a low level of financial investment and technical input and is very labor intensive, with low levels of mechanization, production and efficiency. Miners typically gain a small income from

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mining and are simultaneously engaged in other activities such as subsistence agriculture. According to Dreschler (2001), artisanal gold mining is associated with mushrooming of unplanned squatter camps located close to water courses with poor or no sanitary facilities. This development has high chances of considerable amount of water pollution from human waste. He also argues that 80% of the operations are open casts or shallow pits less than 30m deep and there are left uncovered and unprotected. This kind of land disturbance resulting from gold panning activities leave a noticeable effect on the siltation of rivers and dams, deterioration of water quality, reduction of grazing land for animals and the overall reduction in biodiversity. In some cases, underground operations require the opening up of adits, vertical shafts; winzes and raises as well as underground tunnels leading to land subsidence.

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Predominantly, a bulk of the mining regions of Ghana have for a long time been the Ashanti, Eastern and Western regions, and over the years enlarged to the northern part where the Upper East Region, formerly known as the North Eastern Corridor of the then Northern Territory of Ghana, was identified to have some mineral deposits like coal, manganese and gold. The first ever mining exploration in the Upper East Region was done in Nangodi in the Talensi-Nabdam District but was abandoned by the Russian Miners in 1934 (Hilson, 2001). Over some years now, studies have been made on the Artisanal Gold Mining activities in the region like that of Agyeman and Aghetara, but none of these studies was conducted in the Builsa North though the activity in recent times it extended to the Builsa North District which has been in existence in about 10 years now. This study therefore is the first ever to be conducted in the district with regards to artisanal gold mining and it seeks to uncover the nature of artisanal gold mining, the environmental and health implications as well as

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households coping strategies of Artisanal gold mining activities in Kadema in the district.

1.3 General and Specific Research Questions

The main research question: What are the environmental and health implications of artisanal scale gold mining in Kadema?

Specifically, the research seeks to answer the following questions:

i. How is ASGM practiced in Kadema?

ii. What has been the implications of the mining operations on the natural environment?

iii. How have the operations affected the health of people?

iv. How are households coping with the negative externalities of ASGM?

1.4 General and Specific Research Objectives

The main aim of the study is to assess the environmental and health implications of artisanal gold mining in Kadema.

The specific research objectives are:

i. To examine the nature of ASGM practices in Kadema.

ii. To ascertain the implications of artisanal mining on the natural environment.

iii. To assess the effects of artisanal mining on the health of people.

v. To understand households' coping strategies to the negative effects of artisanal mining

1.5 Scope of the Study

The Builsa North District is one of the 13 administrative districts in the Upper East Region of Ghana, where the study was conducted. The district is endowed with very rich natural resources. Preliminary exploratory work carried out in the district

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indicates that Builsa abounds in large quantities of several mineral deposits ranging from Gold, Chromites, Rutile Jasper Talc, Lime, Feldspars, Nepheline Syenite and varied types of clay (GSS,2010). Due to the endowment of minerals in the community, artisanal small scale gold mining is being carried out in the sub communities of Kadema in the district. The study therefore is being carried out to assess the environmental and help implications of this activity within the district which is the first study that is being considered.

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1.6 Significance of the Study

In light of the catastrophes stressed in the background, this study is significant to the local community, government, policy makers and disaster managers in that it offers a step towards good land management practices that are vital in sustainable resources (water, land, quatic life forms – flora and fauna) management. This study exposes the effect of artisanal gold mining on water quality and quantity and consequently contributes in forming the basis of studies on forthcoming modeling of the river basins in the locality thereby leading to decline in future tragedies. The study raises mindfulness to the worried people on the possible dangers and risks they are facing. Thorough knowledge of the hazards and risks faced helps the community develop coping strategies that are pertinent to specifications. In a nutshell, the study prepares the communities involved and makes them extra resilient to hazards hereafter, a resilient and calamity free community. It also seeks to undertake a thorough look into the environmental and health effects of artisanal gold mining on surrounding communities, both negative and positive, and recommend policy directives as well as reducing the rate of hazardous health effects of the mining activities that may be

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identified in Kadema and other surrounding towns. Findings and recommendations will serve as guide to other mining sites in the country.

1.7 Limitation and Ethical Considerations

All research effort has peculiar challenges and this study is no exception. The difficulties that are likely to be faced during the study will comprise hostility and absence of participation by some artisanal miners who regard the researcher as a stranger and undesirable intruder. They might endorse this to the difficulties they always encounter with the police who would intend to enforce law. Non-cooperation will be encountered with stakeholders since some sought to protect their information. This study is also not funded and as such; the researcher had to bear the total costs.

ASGM is an informal and illegal sector in Ghana; there are limitations in getting enough information. In most parts of the sub-region, communities who are involved in ASGM activity are afraid to tell their real story and income as the practice is illegal.

The research was conducted using local languages in Builsa area. Though investigators have 80% capacity to understand the thoughts and arguments of the respondents, it will be difficult to grasp all. The researcher is also constraint in getting adequate secondary data information because of the lack of previously conducted study in the sector in addition to the lack of enough databases in the district in relation to ASGM activities.

As ASGM in Kadema is illegal and informal, the researcher had the duty in ensuring the ethical standard of the study. In order to acquire sufficient information and safeguard the research participant's privacy and safety the study will provide ample information on the objective, significance and nature of the study and in using them

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secretly in my study finding by creating good relationship between the investigator and participants.

1.8 Organization of Thesis

This thesis is organized in five chapters. Chapter one (1) as presented involves the introduction to my research topic, the research objectives and research questions, the study area and a brief description of my methodology of my research. The second chapter covers the literature review and presents literature that is related to my topic of study. Chapter three (3) presents the methodology and the method used in the collection of empirical data. In Chapter four (4), the empirical findings from the research on the field are presented and analyzed in the light of the conceptual frameworks that are outlined in the literature review. In Chapter five (5), conclusions are drawn and some suggestions and recommendations are made.

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CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

Numerous studies have been piloted on mining, its effects and influences to economic development of nations gifted with mineral resources especially gold. Some studies focus on the benefits of mining to economic development, others on the undesirable externalities of mining on the overall development of such economies. This section reviews what has been documented regarding mining, processes and the methods employed in ore extraction. The chapter also looks at impact on the environment and health of the people to the mining areas as well as households coping strategies**.**

2.2 The Concept of Artisanal Gold Mining

The definition of "artisanal and small-scale" mining is not uniform in many jurisdictions. The term "artisanal" refers to the rudimentary type of the operation, independently whether the mine is small or large, while small scale mining refers only to the size of the operation, and these can operate in a conventional or in a rudimentary fashion (Veiga, 1997). Very often the legislations of developing countries refer to "artisanal and small-scale mining" as "individuals, groups, families or cooperatives mining with minimal or no mechanization, often in the informal (illegal) sector of the market" (Hentschel et al., 2002).

Hilson (2002) described that an artisanal mining operation is that one with "intense labor activity located in remote and isolated sites using Rudimentary techniques and low technological knowledge, low degree of mechanization, and low levels of environmental, health and safety awareness". Efforts to create a clear distinction between artisanal and small-scale miners, just like efforts to clearly define ASM in the international arena, have failed (Veiga et al. 2006). ASM actually represents a spectrum of mining activities ranging from individuals panning for gold or precious stones along riverbanks, to relatively large and organized operations (Hinton 2006; Veiga et al. 2006). While some countries make a distinction between 'artisanal mining' and 'small-scale mining' in their legislation, others (e.g. Ghana) do not. However, most countries now have mining legislation and regulations differentiating between large-scale (or industrial mining) and ASM. ASM is generally distinguished from industrial mining by a low level of production (although in some regions, e.g. Brazil, this can be high); relatively low degree of mechanization/technological development (e.g. miners often use picks, chisels, sluices and pans); high degree of labor intensity; little capital investment; lack of long-term planning; informality; and poor occupational health, safety and environment conditions (Chaparro Ávila 2003; Hinton et al. 2003b; Lahiri-Dutt 2004; Hinton 2006; Adler Miserendino et al. 2013). Other characteristics of ASM include (Chaparro Ávila 2003; Hinton et al. 2003b; Hinton 2006; Adler Miserendino et al. 2013); Widespread geographical distribution, Decentralized activities, An employment option in remote rural regions, reducing rural-urban migration, Supplies local markets , Stimulates local economies, Generates local production chains, Encourages geopolitical development, Often discovers new deposits (but can involve extraction of primary or secondary ores), Encourages larger projects, Involves a number of stakeholders as well as Leads to social conflict.

The International Council on Mining and Metals (ICMM 2009b) has classified ASM into five categories (which are by no means mutually exclusive, and a combination of these categories will generally be found in any given ASM location): Traditional – ASM that has occurred for generations in a given area and may form part of traditional livelihoods though the Seasonality of ASM complements other seasonal

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livelihoods, such as agriculture or the rearing of livestock. Quite apart, Permanent Co-habitation of ASM that takes place in areas connected with large- or medium-scale mining, such as miners working in abandoned areas, in tailings dams, or downstream of the larger operations could cause Shocks when unexpected events, such as drought, economic collapse, commodity price fluctuations, conflict, retrenchment from mining parastatals, and unexpected commercial mine closure drive individuals into ASM as well as the Influx opportunistic in-migration or an influx of ASM miners to an area where minerals have been discovered.

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ASGM activities are quite diverse. Sometimes illegal or informal, often barely tolerated by authorities, ASGM activities can be seasonal or year round, long-term or following a boom-and-bust cycle (Buxton, 2013). ASGM demographics vary considerably, and all age groups can be represented. Communities may comprise local populations or may be generated through extensive in-migration. ASGM can be a family-based subsistence activity in which men, women and children participate throughout the mining work process. Some artisanal and small-scale gold miners are characterized as poor, migrant and seasonal workers who divide their time between mining and other economic endeavors (Phillips et al., 2001; World Health Organization, 2001). The typical mining process in artisanal and small-scale mining in Ghana involves exploration, development, material handling, processing and marketing as described by Bansah et al. (2016). However, mineral exploration in ASGM in Ghana is typically informal (Amankwah et al., 2015; Bansah et al., 2016). ASGM operations exploit marginal or small deposits, lack capital, labor intensive, have poor access to markets and support services, low standards of health and safety and have a significant impact on the environment (MMSD, 2002).

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Hilson (2002:864) defines 'ASM' as an encompassing label for the non-mechanized, labor demanding activities of the mining sector in which its operations and management techniques makes it unique" Unlike the large scale mining activities which is highly mechanized with machinery and skilled workers, small scale mining activity are generally rudimentary and portrayed as a highly manual process. While men work primarily in the mines, women and children can work both in and around the mines and at home, balancing mining and household responsibilities. This blend of mining and household work results in an array of health problems for miners, family members and surrounding communities. Many of these health problems can be exacerbated by the absence of regulation in the ASGM sector; lack of miner education about health hazards; limited access to protective equipment and limited technical knowledge due to lack of access to technical training, low levels of education or low literacy rates (Wall, 2008). In cases where ASGM operates formally, health problems can be exacerbated by lack of miner access to technical and financial resources needed to adopt more sophisticated mining practices.

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ASGM communities often have little or no access to safe drinking water, adequate sanitation or health care. The problem is compounded when mining occurs in remote locations or when massive immigration increases patient flow and subsequent pressure on the local health-care system. While gender roles may vary, in general, men have greater access to and control over land and resources (Eftimie et al., 2012). Men are typically more involved in decisions regarding mining exploration, prospecting and benefits distribution, while also being directly involved in the mining work process (Eftimie et al., 2012; Hinton et al., 2003a). A study of artisanal and small-scale gold miners in Mongolia found that male miners belonged to one of two groups, the first of which comprised men who had a long history in artisanal and small-scale mining and were more aware of the health risks associated with their work. The second group included younger men whose lack of experience resulted in more risk-taking behavior, particularly in relation to the use of safety measures and personal protective equipment (Pfeiffer et al., 2013). Female participation in artisanal and small-scale mining varies around the world: women make up 10% of the artisanal and small-scale mining population in Asia, 10-20% in Latin America and 40-50% in Africa (Hinton et al., 2003a). This variation is further reflected in their mining roles. While often excluded from underground extraction, women participate in a variety of tasks both inside and outside the mine (International Labor Organization, 2007). In the Philippines, for example, women are primarily involved in amalgamation and burning, while men are primarily involved in ore extraction and processing (Lu, 2012). In Bolivia, women mainly gather and process ore, often by hand, for example using sledge hammers (Bocangel, 2001). In Africa, female miners can take part in all aspects of mining - digging, crushing, transporting, sorting, processing and trading (Lu, 2012). Women are also often simultaneously responsible for all domestic tasks, such as preparing food, caring for children, cleaning, etc. (International Labor Organization, 2007). In some locations, women also supply food and drink, tools and equipment, and sexual services (Yakovleva, 2007).

The ILO estimates that nearly one million children between 5 and 7 years of age are engaged in small scale mining and quarrying activities worldwide (International Labor Organization, 2005). Children can be involved in virtually all stages of ASGM, ranging from ore extraction, to processing, and burning. Some children are also required to run errands, carry heavy equipment or materials, or deliver food and water to miners working deep within the mines (International Labor Organization, 2003). Tasks performed by young boys and girls also vary. For instance, girls involved in

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ASGM often participate in wet and dry panning, extraction, and amalgamation. Girls are also often involved in domestic activities in and around ASGM sites and processing areas. Boys on the other hand, are more typically involved in extraction and processing (International Labor Organization, 2005). Almost all work performed by children in artisanal and small-scale mining is hazardous and has characteristics that fit the definition of a "worst form of child labor" under ILO Convention No. 182 (International Labor Organization, 2005). It is difficult, however, to eliminate or limit the participation of children in artisanal and small-scale mining, given its family orientation, transient and informal nature, and associated levels of poverty.

Artisanal and small-scale gold mining is defined in the Minamata Convention on Mercury as "gold mining conducted by individual miners or small enterprises with limited capital investment and production" (United Nations Environment Programme, 2014). The International Labor Organization describes artisanal and small-scale mining as "…labor intensive, with mechanization being at a low level and basic" (Jennings, 1999). Building on this description, the World Bank's Communities, Artisanal and Small-Scale Mining (CASM) initiative elaborates on the economic and social effects of artisanal and small-scale mining work as "… largely a poverty driven activity, typically practiced in the poorest and most remote rural areas of a country by a largely itinerant, poorly educated populace with little other employment alternatives" (World Bank, 2013). Most definitions of artisanal and small-scale mining share the following characteristics: an informal work sector, limited use of mechanical tools, labor-intensive work, low capital and productivity, deposit exploitation, and limited access to land and markets (Hentschel et al., 2003; Mining, Minerals and Sustainable Development, 2002). These characteristics illustrate the cycle of poverty that can exist in artisanal and small-scale mining communities,

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particularly where inefficient mining and processing techniques yield a small quantity of product and low profit (Barry, 1996). Further compounding this cycle are the health and environmental hazards associated with this type of work.

Artisanal and small-scale gold mining is carried out in over 70 countries by approximately 10-15 million miners including approximately 4-5 million women and children (United Nations Industrial Development Organization, 2006b; Telmer & Veiga, 2009). While ASGM activities occur all over the world, they are most prevalent in South America, Africa and Asia (Hinton, 2006; Böse-O'Reilly, World Health Organization, 2013a, 2014).

ASGM usually comprises the following steps:

Firstly, Extraction: Miners exploit alluvial deposits (river sediments) or hard rock-deposits. Sediment or overburden is removed and the ore is mined by surface excavation, by tunneling or by dredging (in the case of alluvial mining) (United Nations Environment Programme, 2015).

Secondly, Processing: In this step, the gold is liberated from other minerals. The methods used for processing can vary depending upon the type of deposit. Gold particles in alluvial deposits are often already separated and require little mechanical treatment. While for hard rock deposits, crushing and milling are required. Primary crushing can be done manually, for example using hammers, or with machines. Mills are then used to grind the ore into smaller particles and, eventually, fine powder.

Thirdly, Concentration: In some cases, gold is further separated from other materials by concentration. Different methods and technologies (e.g. sluices, centrifuges, vibrating tables, etc.) may be used to concentrate the liberated gold. The density of gold compared with other minerals in the ore is often higher. Therefore many

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techniques utilize gravity for concentration (United Nations Environment Programme, 2012).

Moreover, Amalgamation: Elemental mercury is used to obtain a mercury-gold alloy called an “amalgam” (roughly equal parts mercury and gold). There are two main methods used in ASGM for amalgamation: whole ore amalgamation and concentrate amalgamation. In whole ore amalgamation, elemental mercury is added with little prior combination and concentration. Large quantities of mercury are often used (between 3-50 units per unit of gold recovered) and most is released as waste into the mine tailings because of the resulting inefficiency of this process (Sousa et al., 2010; United Nations Environment Programme, 2015). For this reasons, whole ore amalgamation is included in Annex C of the Minamata Convention on Mercury as an “action to eliminate” (United Nations Environment Programme, 2014). In concentrate amalgamation, the mercury is added only to the smaller quantity of material (“concentrate”) that results from the concentration step. As a result considerably less mercury is generally used. Excess mercury can also be recovered. (United Nations Environment Program, 2015).

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Burning: Thus, the amalgam is heated to vaporize the mercury and separate the gold. In “open burning”, all of the mercury vapour is emitted into the air. Open burning of amalgam or processed amalgam is, therefore, also considered an “action to eliminate” in Annex C of the Convention. The gold produced by amalgam burning is porous and referred to as “sponge gold” (United Nations Environment Programme, 2015) and,

Finally, Refining where the Sponge gold is further heated to remove residual mercury and other impurities. Methods and technologies used in the ASGM process can vary significantly from place to place, while the use of mercury in mineral processing is

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actually illegal in many countries, mercury amalgamation is the preferred and most common method of extracting relatively fine gold from ore in ASM (Veiga et al. 2006). When mercury comes into contact with gold particles (in sediments or crushed ore), it forms an amalgam, which is then heated to evaporate the mercury, which leaves the gold behind (UNEP and Artisanal Gold Council 2012).

UNEP and Artisanal Gold Council (2012, pp. 10-1) outline the steps in extracting gold using mercury as follows: Rocks or sediment containing gold are mined, If necessary, the ore is crushed to liberate gold particles, Frequently, the gold bearing material is concentrated to reduce mass where Mercury is added to extract the gold by forming an amalgam (mixture of mercury and gold) and Amalgam is collected and heated, evaporating the mercury, and leaving a porous 'sponge gold' product, 'Sponge gold' is melted to produce solid gold doré and the doré is refined in gold shops to 24K and traded internationally.

This process releases mercury in two forms – metallic mercury, which is discharged into the environment (air, water and soil) and released through burning, and mercury vapour, which is inhaled (Tschakert & Singha 2007; UNEP and Artisanal Gold Council 2012). ASM is the biggest source of mercury pollution to air and water globally, and is second only to coal combustion in terms of anthropogenic sources of mercury emissions to the atmosphere (Kessler 2013; UNEP 2013a).

Mercury is used in the process of extracting gold from ore for a number of reasons (adapted from Binali 2012; UNEP and Artisanal Gold Council 2012) because it is Quick and easy and independently - it can be used by one person independently.it is also Effective at extracting gold at most ASM sites and Typically very accessible as well as Cheaper than most alternative techniques.

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Artisanal and small-scale mining (ASM) of gold (Au) has been studied worldwide due to the use and release of mercury (Hg) to the environment (Veiga, 1997; Veiga et al., 2006, 2009; Shandro et al., 2009; Spiegel and Veiga, 2010; Velasquez-Lopez et al., 2010). The Global

Mercury Assessment (UNEP, 2013) estimated that ASMof gold released ~727 t (metric tonnes) of Hg to the environment per year. This is 37% of the global 1960 t of Hg released annually by anthropogenic sources to the environment (UNEP, 2013). Such numbers are corroborated by various studies specifically on ASM of Au (Cordy et al., 2011; Bose-O'Reilly et al., 2010; Paruchuri et al., 2010; Castilhos et al., 2006).

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2.3 The Environmental Implications of ASGM

Mining by its very nature is not a sustainable activity as its production processes involve

Clearing of forests, removal of large quantities of soils, use of large quantities of water, and

Emission of gases and particles into the atmosphere (Orguela, 2012; Silengo & Sinkamba n.d; Cross, et al., 2010 and International Institute for Environment and Development [IIED], 2002).

Many rural households in sub-Saharan Africa heavily depend on environmental resources for their day-to-day lives (United States Agency for International Development [USAID], 2006). However, millions of these community members and individuals live in poverty and experience food insecurity due natural disasters, political conflicts and wars as well as human activities which have resulted in dwindling livelihoods and increased vulnerability. According to Pedro (2004), mining has the potential to reduce poverty and contribute to sustainable development if proceeds are used prudently. Governments should therefore demonstrate mineral

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potential and viability for mineral extraction and creating a conducive environment which attracts investors while balancing this with the needs of local communities (IIED, 2002).

Mining involves the removal of large quantities of vegetation and soils to make way for mining activities. Depending on the types of minerals extracted and technology used mining can have significant impacts on the environment from environmental degradation to air pollution and contamination of both surface and underground water, and loss of biodiversity (Silengo & Sinkamba, n.d; IIED, 2002; Lungu & Shikwe, 2006; Cross et al., 2010; Mwitwa et al. 2012; (Durucan et al., 2006; Peck & Sunding 2009) cited in Orguela, 2012). Lufwanyama is a watershed area with various water courses and vegetation types such as the *miombo* woodlands (Choongo, 2004; Shulumi, unpubl.). Use of open cast and illegal mining in the extraction of emeralds is a threat to this fragile environment while waste dumps permanently degrade the environment and large open pits are a permanent scar on the earth surface and if not properly rehabilitated can have adverse impacts (IIED, 2002; Silengo & Sinkama, n.d).

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Mining has a multiplier effect in development as it create jobs directly and indirectly, can contribute to infrastructure development and also improve the well-being of communities through access to education, healthcare and transfer of skills. Where proper linkages have been created through diversification, value addition and local community supply systems, business opportunities are created, and wealth generated for local and national economies. However, in most resource rich countries, mining is not making significant contributions due to lack of infrastructure, value addition and fewer benefits to communities and more to central governments (Crowson, 2010 cited

Orguela, 2012). Most mining projects do not benefit the immediate local communities as most labour is obtained from neighbouring areas.

Mining does result in the loss of access to land and forest based resources communities depend on heavily, such as timber and non-timber forest products (NTFPs) for subsistence and incomes (Mwitwa, Muimba-Kankolongo, German & Puntodewo, 2012).

Loss of access to land and Environmental resources can also result from dislocation. Poor compensation of dislocation victims regarding lost land (Custer & Nordband, 2008) is very common and van Wyk (2010) argues that emphasis should not be on relocating them but on rehabilitating them. Deforestation is a common feature where forests are cleared to pave way for mining, infrastructure developments, shelter and food and also from charcoal production activities.

Mineral development has inevitable adverse impacts on local development, environment and Urban ecology. This consequently result in the whole process of mining-led development being characterized with conflicts between corporate mining objectives, recipient community needs and governmental policy goals for regional development (Oyejide and Adewuyi, 2011; Bice, 2013). Given the wide range of environmental and social discontents that are associated with the activities of the mining industry, as discussed in past literature (Moody and Panos, 1997; Warhurst, 2001; Dale 2002; Peck and Sinding, 2003; Richards 2009),most mining communities are therefore perceived to experience ‘poverty in the mist of plenty’ (Oyejide and Adewuyi, 2011). The environmental deterioration caused by mining occurs mainly as a result of wasteful and inappropriate working practices and rehabilitation measures. Akabzaa, (2000) argues that mining has a number of common stages; each of it has a potential adverse impact on the natural environment, society and cultural heritage, the

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health and safety of mine workers and the environs of mining communities. Potentially adverse impacts of mining range from the degradation of the natural environment to the displacement of local people as well as the marginalization and oppression of people belonging to lower economic classes (Tauli-Corpuz, 1997; Ahluwalia 2007; Li et al, 2012).

Air, climate, water resources, soil and vegetation form the vital environmental variables that the study looks. Now, the effects of surface mining on these variables and the impacts on the livelihood of the local populaces. Surface mining denies local people of large proportion of lands for cultivation, which constitute the fundamental economic activity for family wellbeing and survival. This is well manifested in the proportion of lands it seizes for its operation. Stickler (2006) confirms in his studies that for surface mining to take place, one needs about six times the land surface needed for underground or deep mining to operate a surface mine. the high incidence of cyanide mismanagement by several gold mining firms have led to the cyanide contamination of freshwater resources and soils, adversely impacting local fish and wildlife populations and the health and livelihoods of rural farming and indigenous communities. This happens after the ore is extracted, crushed into rubble, piled up in heaps, and sprayed with a weak cyanide solution to extract the gold. The cyanide-laced water and sediment is stored in massive plastic-lined tailings ponds that are supposed to hold the cyanide waste, but the ponds inevitably leak or the dams restraining them fail, allowing cyanide to pollute the water table or nearby rivers and streams (Akabzaa & Darimani, 2001). One of the worst cases of cyanide spillage was caused by Goldfield (Ghana) Ltd in 2001 when a tailings pond of the company ruptured, sending several thousand cubic meters of cyanide-contaminated water into the Asuman River and its tributaries at Abekoase in the Western Region which

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resulted in several health hazards for the local people residing around these water bodies (Anane, 2003; Hilson, 2006). The physical environment of most people living in communities where the operation of Large-Scale. Surface Mining is ongoing is characterised with noise, vibrations and acidic rain. This situation has created poor living conditions for local people due to the huge level of noise and vibrations. Again, it also brings about substantial levels of cracks and weakened foundations in most buildings most especially ones that are just a stone throw from the operation site. In terms of incidence of acidic rain in such communities, the roasting of ore containing pyrite gives a rise to the production of SO2 in the atmosphere which produces acid rain. The acid water then releases high levels of toxic ions from the rock matrix in the groundwater.

For several decades, Hg has been recognized as an environmental pollutant (Akagi and Nishimura, 1991; Clark, 1997). The Hg pollution problem in the Talawaan Watershed has generated several potential threats to the province to date (Martens, 2000). The immediate health threat of the use of Hg for gold extraction affects those who work or live in areas around processing plants. As regards water pollution, some of the metallic Hg discharged into rivers and waterways is transformed into methyl Hg, by microorganisms then eaten by aquatic species, which are in turn consumed by humans. Like bioaccumulation of many environ- mental contaminants, that of Hg accumulates along the food chain of aquatic organisms (Lodenius and Malm, 1998; Veiga, et al., 1999). Fish and other wildlife from various ecosystems commonly attain Hg levels of toxicological concern when directly affected by Hg emissions from human-initiated activities (Samoiloff, 1989). Hg is used in gold mining to extract gold from ore by forming “amalgam”—a mixture composed of approximately equal parts Hg and gold [Arctic Monitoring and Assessment Programme (AMAP)/UNEP 2013].

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The amalgam is heated, evaporating the Hg from the mixture, leaving the gold (AMAP/UNEP 2013). This method of gold extraction is used in the ASGM community because it is cheaper than most alternative methods, can be used by one person independently, and is quick and easy (UNEP 2012). The dramatic rise in the cost of gold over the last decade has fueled a gold rush by poverty-driven miners in many countries (UNEP 2008). ASGM occurs primarily in South America, Africa, and Asia, but it can also be found in North America and Australia (UNEP 2013c). ASGM is the largest source (37%) of global Hg emissions (UNEP 2013c). Between 2005 and 2010, Hg emissions from ASGM doubled (UNEP 2013a). Although most uses of Hg are declining throughout the world, the ASGM demand for Hg is expected to increase (UNEP 2013c). ASGM accounts for the largest percentage of global Hg demand (UNEP 2013c).

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Hg vapors in the air around amalgam burning sites can be alarmingly high and almost always exceed the World Health Organization (WHO) limit for public exposure of 1.0 $\mu g/m^3$ (UNEP 2012). These exposures affect not only the workers but also those in the communities surrounding the processing centers (UNEP 2012). Drake et al. (2001) reported that the range of the 8-hr time-weighted average airborne Hg exposure at gold mining operations in Venezuela was 0.1–6,315 $\mu g/m^3$ with a mean of 183 $\mu g/m^3$. The WHO (2000) reported that tremor has been observed in workers exposed to 30 $\mu g/m^3$ Hg and that renal tubular effects and changes in plasma enzymes are estimated to occur at 15 $\mu g/m^3$. The vaporized Hg eventually settles in soil and the sediment of lakes, rivers, bays, and oceans and is transformed by anaerobic organisms into methylmercury (MeHg). In bodies of water, the MeHg is absorbed by phytoplankton, which is ingested by zooplankton and fish, thereby contaminating the food chain. It especially accumulates in long-lived predatory species such as shark and swordfish (WHO 2007).

ASM is an important livelihood strategy in developing nations, and in Africa in particular (Economic Commission for Africa 2011). However, it is associated with many negative social, environmental and health impacts and presents particular sustainable development challenges. Numerous universities, NGOs, associations, companies and governments are working to find approaches to the challenges of ASM, which include lack of formalization and regulation, poor environmental practices, health and safety hazards, child and forced labour, security and human rights risks, conflicts with large-scale mining, issues around relocation, and inequitable distribution of benefits (ICMM 2009).

The ASGM process frequently leads to degradation and contamination of the general environment. These environmental hazards have implications for the health and well-being of miners, surrounding communities as well as for the global environment. The most commonly cited ASGM-associated environmental hazards include land degradation, mercury emissions/pollution, siltation, erosion and water contamination. In Ghana, the environmental impacts of artisanal gold mining (mostly surface operations) have included water contamination, destruction of flora and fauna, land degradation, and mercury contamination of soils and water (Aryee et al., 2003; Babut et al., 2003; Hilson, 2002; Bonzongo et al., 2003). There are also reported cases of disregard for basic safety protocols resulting in death, damage to property and to the environment (Al-Hassan & Amoako, 2014). Mining is one of the key areas of natural resources exploitation in tropical countries like Ghana (Yaro, 2010) and contributed approximately US $ 4 billion in foreign direct investment to Ghana (Yelpaala & Ali, 2005; Garvin, McGee, Smoyer-Tomic, & Aubynn, 2009). Artisanal mining locally

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known as “galamsey” in Ghana, has been given a lot of media publicity, and has created public concern on the perceived extensive damage it has caused to forest cover. From the country's original forest cover of 8.2 million hectares at the beginning of the 20th century only an estimated 1.6 million hectares remain. The deforestation rate is 2.0% leading to an annual loss of around 135.000 ha (Ministry of Lands and Natural Resources, 2012). With the dependence on forest as a source of livelihood to local people, protection of the remaining natural forests may be a difficult goal to achieve given socio-economic constraints associated with mining (Appiah et al., 2009). Although illegal mining could help reduce poverty, on the contrary, it could bring negative impacts on forest resources (Sachs & Warner, 2001)

Destruction of forest, loss of habitats and biodiversity, due to mining activities, has been widely reported (WWI, 1992; Majer, 2013). Though mining is important it is said to be illegal when it is practiced without permit or in unapproved areas like the forest reserves, game reserves or near water resources even with a secured permit (World Bank Group Department, 2002). Artisanal gold mining in Ghana, has been given a lot of media publicity, and has created public concern on the perceived extensive damage it has caused to forest cover. Though, Deforestation and forest degradation, primarily in developing countries, accounts for some 18% of global carbon dioxide emissions (IPCC, 2007). In Ghana most of the accessible rainforests are shrinking due to the combined effect of forest fires, logging, agricultural colonization, mining activities, wild land fires and other development projects (Hansen et al., 2009).). A similar study by Hilson (2002) noted that small-scale mining activities in Ghana destroy vast tracks of forest which exposes fertile lands to erosion and other forms of degradations. Eventually, farmers lose their farm lands to these mining activities which can hamper the development of agriculture in the long

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run (Hilson, 2002). Apart from polluting farm lands which limit the quantity of farm lands available to farmers for farming, mining also strongly competes for the limited fertile lands and unskilled farm labor. The wastewater is often discharge directly into sewers, ditches, ponds or streams which are used as farmland irrigation water. Besides of economic profit from small scale gold mining (Hilson 2002a; Eriyati and Iyan, 2011; Hoedoafia et al., 2014), there is several environmental damage caused by the activity (Hilson, 2002b; Kessey and Arko, 2013). According to Polii and Sonya (2002), mercury can enter human body through food and breathing. . However, several studies are reporting that artisanal, informal mining also gives rise to environmental problems (e.g.Tarras-Wahlberg et al., 2000; Hilson, 2002; Babut et. al., 2003; Waziri, 2014) and that the consequences could be more serious due to higher levels of exposure, in addition to the fact because these non-formal operations are hardly regulated by government agencies, their impact on the environment may go completely unnoticed. Miners there were quick to adapt their processing methods to the characteristics of the ore they are mining. This type of technology adoption at ASM sites has been widely documented throughout the world, including in Ghana (Hilson, 2002; Hilson and McQuilken, 2014; Teschner, 2012), Mali (Hilson, 2013; Teschner, 2014), Suriname (Heemskerk, 2011), and elsewhere in the Philippines (Verbrugge, 2014). The finding of this study confirm reports that associated a plethora of environmental complications such as mercury pollution, reduction in vegetation cover and land degradation with such illegal activities despite providing people with employment, and making important contributions to foreign exchange earnings (Hilson, 2002; TomDery, Dagben, & Cobbina, 2012). Hilson (2002) suggested that these problems could be attributed to low safety awareness and levels of training, poor exploitation of available resources due to selective extraction of rich ores, absence of

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environmental standards and utilization of highly inefficient equipment. An estimated 15 million operators scattered across 70 countries release in the range of 1400–1600 t of mercury every year (Gibb and O'Leary, 2014; United Nations Environment Program (UNEP, 2013; Veiga et al., 2014). After amalgamating their gold, most of these miners discharge excess mercury into the natural environment where, as several timely reviews have captured over the years (e.g. Wren, 1986; Stein et al., 1996; Selin, 2011), it methylates and bio accumulates, posing a range of health-related threats to humans and wildlife.

Coomson (2004) describes land degradation as the major impact of ASGM on the environment in Ghana. Flora and fauna are destroyed in the process of mining. The dimensions of surface ASGM openings vary from shallow, greater than 30 m to deep depths, less than 30 m. The mining of deep deposits typically produce wider openings than shallow deposits. The openings are often left unclaimed after the ore extraction. Small scale underground openings are commonly not back filled after mining. These openings have the tendency of collapsing and trapping or killing farmers, hunters, and animals. Water may also fill abandoned stopes or pits, serving as potential breeding zones for mosquitoes. In Ghana, land degradation from small-scale mining activities is a problem that has been examined at length in a number of publications (e.g. Hilson 2002a; Hilson 2002b; ActionAid Ghana 2003; Aryee 2003; Aryee et al. 2003). During the early-1990s, the government made an ambitious attempt to post a reclamation bond for small-scale mining, retaining 3% of proceeds from mineral sales to PMMC for land restoration purposes. Initially, the move was successful, generating some US$17,000 during its first few years of existence. However, as indicated in the GTZ commissioned study undertaken by Kwame Asante & Associates, 1993, the resulting uncompetitive price led a number of miners to sell gold to illegal gold buyers, thereby

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forcing the government to abandon the Land Reclamation Bond outright. Although the economic significance of ASM in Ghana cannot be underestimated, it has often been cited for environmental damage and health issues (Babut *et al*., 2003; Aryee *et al*., 2003; Hilson *et al*., 2007). One of such environmental issues is massive land degradation. Indeed, it is not uncommon to find abandoned degraded ASM sites in Ghana. According to Nyame and Blocher (2010), arable lands used for ASM operations are left unclaimed, rendering the lands barren and uncultivatable. In the Western and Eastern regions of Ghana for example, disturbed ASM sites are abandoned without any form of reclamation to restore the productive capacity of the land, or to better uses, to ensure sustainability. Recent mechanization of the ASM sector has widened the scale of the mining operations and increased the level of environmental degradation, resulting in large unclaimed open areas. The absence of reclamation in ASM according to some operators is partly due to lack of funds and technical support.

To demonstrate commitment to environmental and health protection, and to ensure sustainability in ASM, Zenon Mining Company, located in Kwabeng in the Eastern Region of Ghana integrates reclamation into mine planning to make it a key ruling factor in the mining operations, waste disposal, and site closure as indicated by Johnson *et al*. (1994). The mine is owned and operated by Amina Tahiru- a strong-willed woman entrepreneur and ASM operator. For over two years, Zenon Mining Company utilized innovative partnership (that involves participation of members from host communities) and reclamation methods to progressively restore mined pits into economic resource for local population. ASM operations are left unclaimed, rendering the lands barren and uncultivatable. In the Western and Eastern regions of Ghana for example, disturbed ASM sites are abandoned without any form of reclamation to

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restore the productive capacity of the land, or to better uses, to ensure sustainability. Recent mechanization of the ASM sector has widened the scale of the mining operations and increased the level of environmental degradation, resulting in large unclaimed open areas. The absence of reclamation in ASM according to some operators is partly due to lack of funds and technical support. From the country's original forest cover of 8.2 million hectares at the beginning of the 20th century only an estimated 1.6 million hectares remain. The deforestation rate is 2.0% leading to an annual loss of around 135.000 ha (Ministry of Lands and Natural Resources, 2012). With the dependence on forest as a source of livelihood to local people, protection of the remaining natural forests may be a difficult goal to achieve given socio-economic constraints associated with mining (Appiah et al., 2009). The main environmental damage in this region is soil degradation, land damage and river pollution (Tiffany, 2012). Also, the presence of several abandoned open pits scattered in areas of ancient or recent gold mining cause's severe disturbance of the land surface and disappearance of cultivable land and gallery forest (Joseph & Joseph, 2013).

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ASGM of alluvial gold is believed to be the major cause of river water pollution in Ghana (Al-Hassan & Amoako, 2014; Aryee et al., 2003). Land degradation, in the form of clearing of large areas of forest and vegetation in order to mine ore, results in short- and long-term environmental and health effects. The creation and subsequent abandonment of pits and trenches leave surrounding communities susceptible to loss of arable land, loss of livestock, lack of clean water, stagnant water and malaria-carrying mosquitos (Hilson, 2001). Environmental degradation can also have a major impact on availability of food particularly where it affects agriculture, fishing, hunting and gathering, or other subsistence activities carried out to produce or procure food.

The few papers that have attempted to tease out the causal component have focused on the effect of mining on agricultural productivity: Aragon and Rud (2015) estimate that mining in Ghana reduced agricultural productivity in nearby areas by almost 40%; and on spillovers to non-mining activities Aragon and Rud (2013). The ecosystems of the environment are highly endangered by increased ASM activities. Mangroves and Wetlands are not saved by miners all over the sphere so far as certain minerals can be found howbeit minor or great deposits. The United States has lost at least 54% of its wetlands and European countries have lost up to 90% of their wetland ecosystems. Mining in Ghana is not new: dating back to several decades especially in the southern belt though the Northern regions are hot spots now. However, land degradation and environmental burden from these minerals extraction continue to impact negatively in these mining areas (International Monetary Fund 2004; Duran 2013; Laari et al. 2015). Large tracts of forest cover or vegetation was lost in South America as a result of similar gold mining (Durán et al., 2013; Asner et al., 2013). In Ghana, studies have shown loss of vegetation around gold mining areas (Agyeman, 2007; Schueler 2011). More importantly, Soil which is part of the earth surface upon which food crops and others are grown is highly affected by mining activities. Agricultural farm lands are largely destroyed through mining thereby reducing the availability of farm land, reducing agricultural activities and consequently increasing shortages of food and other agricultural produce. (United Nations Industrial Development Organization (UNIDO), 2006: Tschakert and Singha, 2007).

Air pollution resulting from mining related activities comes from the generation of dust and emission of mine gases especially during drilling, blasting, grinding and crushing of ore. Al-Hassan and Amoako (2014) discuss ambient air quality deterioration by fine particulates released from the sieving of crushed rock obtained

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by small scale mining. In surface operations, dust and emissions are diluted by the wind. However, the confined nature of small scale underground mining (SSUM) operations, dust generated in the stopes accumulates, and serves as a potential health threat to the miners.

Due to the dredging activities and the washing of alluvial gold in the water, siltation is common in major rivers and streams where the miners operate. The operations have also changed some water courses of streams and rivers (Oblokuteye, 2010), depriving downstream users of their only source of water. Fish and other aquatic organism die-off can occur, altering the food web significance. Individuals depending on the rivers for fishing are forced to abandon their source of livelihood resulting in less food availability in the communities. The Bonsa River, for example, which was relied on by farmers and some community members for their source of drinking water and fish has been affected by illegal small scale mining. Piles of excavated materials have been heaped along the river bank with trees felled into the river. The impact of small scale mining on aquatic ecosystem in other parts of Ghana is reported by Babut et al. (2003) and Donkor, Bonzongo, Nartey, and Adotey (2006a). Although the use of mercury for processing of ore has serious adverse effects on human life and the ecosystem, not much attention has been given to mercury contamination in Ghana (Donkor et al., 2006b). Unfortunately, there is no reliable data to assess the extent of mercury contamination in the communities in which mercury is used. Literature available on mercury contamination by artisanal gold mining in Ghana include Bonzongo et al. (2003), Babut et al. (2003), Serfor-Armah et al. (2005), Kwaansa-Ansah et al. (2010) and Donkor et al. (2006a, 2006b). Babut et al. (2003), for example, in a United Nations Industrial Development Organization (UNIDO) study to determine the environmental impacts of mercury prior to the introduction of mercury

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retorts, conducted analysis on river water, soil and fish samples obtained from Dumasi, (a small scale mining village with about 2000 people) in the Western Region of Ghana. The results showed significant contamination of soil sediments. Most of the fish fillets were also found to have accumulated mercury levels that exceed the United States Food and Drug Agency (US-FDA) action level. Anthropogenic mercury emissions have been steadily increasing since 1995. In 2010, it was estimated that annually, 1960 tonnes of mercury were emitted into the air formally by human activities (UNEP, 2013). The AGM sector is responsible for 37% of these emissions. The increasing dependence on mercury by artisanal miners calls for affirmative action to demonstrate non-mercury technologies (Hilson and Pardie, 2006) or at least methods capable of reducing mercury losses (Metcalf and Veiga, 2012). The toxicity of mercury to people involved with ASGM and, to a lesser extent, to the environment, has been well studied (Bose-O'Reilly et al., 2010; Castilhos et al., 2006; Donkor et al., 2006). As most ASGM operations occur near to lakes or along streams and rivers for easy access to water needed for operations, its impacts on aquatic ecosystems can be significant. The impacts of ASGM on aquatic ecosystems vary both spatially and temporally due to the volume and concentration of contaminants being released. During the dry season, ASGM operators draw water from the nearest water bodies for processing. In the wetter seasons, run-off from unregulated ASGM elutriation boxes, slurry channels and sumps, tailing dumps and open pits elevates turbidity, total suspended solids, trace metals and nutrients in streams and rivers, resulting in sedimentation and changes to river morphology and water quality.

In addition to reduced water quality, changes in water quantity of aquatic systems may occur, due to the large volume of untreated mine water pumped directly out of mine pits and shafts into rivers or other water bodies. The Ghana Water Company

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who supplies water for domestic and industrial purposes has complained of increased costs of treatment due to elevated contaminants in raw water drawn from rivers impacted by ASGM (Srem and Andoh, 2013). The contamination of Minamata Bay in Japan in the 1950s engendered an understanding of how elemental mercury is transformed in the environment and the consequent health effects. ASGM activities result in 727 tonnes of mercury being emitted into the air each year (United Nations Environment Programme & Arctic Monitoring and Assessment Programme, 2013), making ASGM the single largest anthropogenic source of mercury emissions to the environment.

In recognition of the significance of this pollution source, the Minamata Convention on Mercury includes a specific Article addressing this practice. Elemental mercury is released during the burning process, emitted into the atmosphere, and later, once oxidized, deposited into soil, lakes, rivers and oceans (United Nations Environment Programme & Arctic Monitoring and Assessment Programme, 2013). Bacteria can transform mercury released into the environment into methylmercury which accumulates in the food chain, affecting fish and shellfish. People whose diet depends heavily on such food are thus exposed to mercury and can have severe adverse health effects. Hilson (2002) finds that small-scale gold mining in Ghana led to socioeconomic growth but also mercury pollution and land degradation. Most studies linking health to mining also focus on correlation and, due to confounding effects, cannot imply causation (Fernandez-Navarro, Garca-Perez, Ramis,Boldo, & Lopez-Abente, 2012; Attfield & Kuempel, 2008; Chakraborti et al.,2013). Metallic mercury is used in mining for amalgamation, the process of separating gold particles from other minerals (Mol, Ramlal, Lietar, & Verloo, 2001).For every kilogram of gold produced, on average 9 kilograms of mercury are released into the environment

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(Pfeier, Lacerda, Salomons, & Malm, 1993; da Veiga, 1997; Guiza & Aristizabal, 2013). Miners add mercury to silt in order to create an amalgam, a bond between mercury and gold. The remaining silt is then washed away. The amalgam is heated in smelters, where the mercury evaporates and the gold nuggets are separated. 55% of the mercury used enters the atmosphere; while 45% infiltrates bodies of water (Pfeier & de Lacerda, 1988) Aquatic Microorganisms transform metallic mercury into methyl-mercury (Morel et al., 1998). The microorganisms are eaten by fish, and in turn humans are exposed to methyl-mercury by consuming contaminated fish (for a more detailed explanation see Mol et al. (2001)).In the U.S., the EPA limits for metallic mercury in drinking water and for methyl-mercury consumption are 0.002 mg/Land 0.1g/kg body weight/day, respectively. There is evidence that those limits are exceeded in Colombia near mining areas (Guiza & Aristizabal, 2013; Olivero & Johnson, 2002). Artisanal and small-scale gold mining is the largest contributor to atmospheric mercury emissions at 727 tons annually, or 35% of anthropogenic emissions. In addition, discharges into water bodies from small-scale mining are estimated at 800 tons each year, representing 63% of anthropogenic releases (United Nations Environment Programme, 2013). Artisanal gold mining over the years has resulted in a wide range of negative impacts on the environment (Kitula, 2006; Aryee et al., 2003; Bonzongo et al., 2003). Tarras-Wahlberg et al. (2001) studied the environmental impacts and metal exposure of aquatic ecosystems in rivers contaminated by artisanal gold mining in the Puyango River basin of Southern Ecuador. Their study found that the discharge of cyanide, mercury and metal rich tailings into rivers of the Puyango catchment area from small scale mining were causing considerable environmental impacts. Cyanide and metal levels in the rivers were found to exceed environmental quality criteria.

Anthropogenic mercury emissions have been steadily increasing since 1995. In 2010, it was estimated that annually, 1960 tonnes of Mercury were emitted into the air from all human activities (UNEP, 2013). The AGM sector is responsible for 37% of these emissions. The increasing dependence on mercury by artisanal miners calls for affirmative action to demonstrate non-mercury technologies (Hilson and Pardie, 2006) or at least methods capable of reducing mercury losses (Metcalf and Veiga, 2012).

In Peru, the number of artisanal gold miners is not well-known. Estimates range from 80,000 (Peru Support Group, 2012) to 150,000 (estimated by some Peruvian authorities in the Ministry of Energy and Mines) of people directly involved. Brooks et al. (2006) estimated that, even with the efforts of international agencies to reduce mercury emissions, between 20 and 40 tonnes of mercury are still released to the environment by artisanal gold miners annually countrywide. This amount appears to be significantly underestimated, given the continued expansion of the artisanal Gold mining sector in the country, in particular in Madre de Dios (Ashe, 2012). Officially, according to the Secretary of Mines of Antioquia, Colombia had 200,000 artisanal gold miners producing 30 tonnes Au/a in 2011. In the Department of Antioquia alone, there are 17 mining towns housing between 15,000 and 30,000 artisanal gold miners. The mercury pollution in Colombia can be as high as 150 tonnes/a giving to the country the shameful first position as the world's largest mercury polluter per capita exclusively from artisanal gold mining (Veiga, 2010). In 2007, Indonesian artisanal miners were releasing 130e160 tonnes of mercury to the environment (Telmer and Veiga, 2008). Recent estimates, from Ismawati et al. (2013), state that the amount of mercury released into the environment in Indonesia can range from 280 to 560 tonnes/a. All Hg-contaminated tailings are leached with cyanide. Many processing plants continue to dump their final cyanidation tailings into the local rivers. Over

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880,000 tonnes of tailings and mining waste are estimated to enter the Puyango River annually, containing about 650 kg of Hg and 6000 tonnes of cyanide (Guimarães et al., 2011). The loss with tailings is due to the formation of small droplets of mercury (known as "flouring") when mercury is submitted to long grinding periods. According to Beard (1987), this loss due to lack of coalescence is caused by mercury oxidation or impurities such as oil, grease, and clay minerals, sulphates, and sulphides on mercury surface. The fine drops of mercury lost with the tailings dumped into the rivers can move long distances associated with the suspended particles (Adler-Miserendino, 2012). Unfortunately, the portion of mercury precipitated along with the zinc, is released to the atmosphere when miners irresponsibly evaporate the zinc shavings to obtain metallic gold (Velasquez et al., 2011).

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2.4 Health Implications of ASGM

The benefits of AGM include job creation and opportunities for local companies, infrastructure and social/community development and financial income (Tiffany, 2012). On the other hand, mining can adversely affect public health and safety, and the environment (Hermanus, 2007). Because these miners are unskilled, underequipped and not knowledgeable, they have little appreciation of the health and environmental impacts of this activity (Samuel M., 2011).

AGM is a dangerous activity as it is a potential source of heavy metal (mainly mercury, lead)

Contamination and toxicity (Jason *et al.*, 2002). Mercury (Hg) is poisonous to both humans and the environment. Chronic exposure to mercury damages the neurological system causing sensory, motor and cognitive disorders (Rasheed & Amuda, 2014). Lead (Pb) is a major metal in gold suphide deposits occurring as mineral mainly in galena (PbS). This is stable under natural conditions, however, once mining has taken place, it is broken down due to exposure to oxygen and water (Jason, Winnie, & Monica, 2002). Exposure to lead takes place mostly through drinking water, breathing polluted air or dust, and eating contaminated food, for example, food grown on soil with high Pb content. The main target for lead toxicity is the nervous system (UNEP/OCHA, 2010). Inhalation of large amounts of siliceous dust, careless handling of mercury during gold panning and gold/mercury amalgam processing, existence of water logged pits and trenches; and large number of miners sharing poor quality air in the mines are the major causes of health hazards among miners (Jason *et al.,* 2002). The most common occupational diseases that workers are likely to develop as a result of long-term exposure in the gold mining environment are silicosis, silico tuberculosis, pulmonary tuberculosis (TB), obstructive airways disease, occupational asthma, oral and/or nasal cavity erosions, diseases owing to ionization radiation, noise-induced hearing loss, whole body and hand-arm vibration syndrome, as well as repetitive strain injuries (Borralho, 2013). Studies on the health impacts of AGM have not been extensively carried out in Cameroon. However, in Bétaré-Oya most miners appear physically well fit, though they report backaches, muscle aches, hernias, respiratory conditions, and high prevalence of malaria (Samuel, Charles, & Gilbert, 2007).

Miners are susceptible to inhaling, absorbing and ingesting chemicals throughout the mining process. The most common chemical exposures in ASGM are to: mercury used to amalgamate the gold; cyanide used to extract gold, for example from tailings; and other chemicals contained in dust and gases. People can be exposed to two forms of mercury in an ASGM context: elemental mercury and organic mercury. Elemental mercury is used in the ASGM process to form gold amalgam. The most important

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direct route of exposure is by inhalation. Highest concentrations of elemental mercury vapors are released when the gold amalgam is heated, for example during the open burning step. This heating process may occur onsite, or at gold shops, or at processing centers, many of which are located in populated areas. Individuals working in or living nearby these facilities and can thus be heavily exposed to elemental mercury vapor, often to degrees that exceed World Health Organization recommended limits (United Nations Environment Programme, 2012; Gibb & O'Leary, 2014). Due to its high volatility, elemental mercury can transform from its liquid state into vapor at typical room temperatures (World Health Organization, 2003).

Individuals can be exposed to elemental mercury vapor if liquid mercury is not properly stored or if surrounding surfaces have been contaminated. Mercury can also volatilize from contaminated waste materials at mining sites (e.g. tailings). Only small amounts of ingested elemental mercury, for example coming from contaminated hands, get absorbed in the gastrointestinal tract (World Health Organization, 2003). Elemental mercury intoxication manifests in neurological, kidney and autoimmune impairment (World Health Organization, 2013a). Symptoms may intensify and/or become irreversible as exposure duration and concentration increase (World Health Organization, 2003). Acute inhalation can directly affect the lung, causing airway irritation, chemical pneumonitis, and pulmonary oedema, with consequent chest tightness and respiratory distress (Agency for Toxic Substances and Disease Registry, 2014). High inhalational exposures can also lead to respiratory failure and death (Landrigan & Etzel, 2013). Mercury has toxic effects on the human nervous, digestive and immune systems, and on lungs, kidneys, skin, eyes, and the brain. It causes neurological damage to children in 25 utero and early in life (Veiga et al. 2006; WHO 2013). Systemic absorption of elemental mercury via the lungs causes nausea,

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vomiting, headache, fever, chills, abdominal cramps, and diarrhea. When ingested, elemental mercury causes direct irritation of the gastrointestinal tract. Chronic, lower level exposure to elemental mercury causes gingivostomatitis, photophobia, tremors and neuropsychiatric symptoms such as fatigue, insomnia, anorexia, shyness, withdrawal, depression, nervousness, irritability and memory problems (World Health Organization, 2003). It can also cause damage to the peripheral nerves and kidneys (Dart & Sullivan, 2004). Elemental and inorganic mercury toxicity in children can also manifest in oedematous, painful, red, desquamating fingers and toes (acrodynia), as well as hypertension (Böse-O'Reilly et al., 2010).

Under certain environmental conditions, mercury released into the environment can be transformed into an organic compound: methylmercury. Bioaccumulation occurs as large fish eat smaller, methylmercury-containing fish, increasing organic mercury concentrations as it moves up the food chain. Due to its greater lipid solubility, methylmercury is more easily absorbed into the bloodstream via the gastrointestinal tract than elemental mercury. Absorption of methylmercury is usually in excess of 90% (World Health Organization, 1990). When circulated throughout the body, methylmercury crosses the blood-brain barrier and accumulates in the central nervous system. The peripheral nervous system and kidneys can also be affected. Symptoms of neurologic disease associated with methylmercury exposure include tingling in the extremities, headaches, ataxia, dysarthria, visual field constriction, blindness, hearing impairment, and psychiatric disturbance, muscle tremor, movement disorders, paralysis and death (Gibb & O’Leary, 2014).

Minamata disease came to light in the 1950s as a result of methylmercury ingestion among fish-eating communities living near the Minamata Bay in Japan. Disturbances in motor and mental development ranged from very severe-newborns with a profound

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cerebral palsy-like presentation-to psychomotor impairment (e.g. abnormalities in chewing, swallowing, speech, gait, coordination, involuntary movement), personality impairment (e.g. extreme shyness, violent behaviour, restlessness, easy startling reflex, inattention or easy distractability), epileptic seizures, and neurological symptoms (e.g. numbness, tingling, abnormal sensory function) (Harada, 1995; Ekino et al., 2007). Studies of Minamata cases confirmed that methylmercury crosses the placenta with ease, and can result in cord blood concentrations that are higher than concentrations found in maternal blood (World Health Organization, 1990). Methylmercury is carried to the developing nervous system where it interferes with normal brain cell migration from the core to surface areas of the brain. In addition, methylmercury binds directly with neural chromosomes and halts cell division. This physiologic interference leads to changes that manifest in the typical neurologic abnormalities, described above. Health effects can vary depending on the dose (the frequency and concentration of exposure) and timing in the neurodevelopment of fetuses and children (World Health Organization, 1990).Those groups at risk of methylmercury intoxication include individuals who consume large amounts of mercury-contaminated fish.

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ASGM populations who also are fish-eaters are at risk for mercury intoxication of both the elemental and the organic forms (Gibb & O’Leary, World Health Organization, 2013a, 2014). Treatment of cases of mercury poisoning Extensive information exists on the use of chelation therapy to treat acute mercury intoxication but information on treatment of chronic mercury toxicity among artisanal and small-scale gold miners is limited (Böse-O’Reilly, 2014).

Due to its high gold recovery rate and low cost, cyanide is increasingly used in ASGM, but often after mercury has already been used, for example on tailings

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(wastes). Mercury-cyanide compounds are easily dispersed in waters and, therefore, can enhance the mobility and/or bio-availability of mercury in the environment (United Nations Environment Programme, 2012). For this reason, the use of cyanide after the use of mercury is an “action to eliminate” in Annex C of the Minamata Convention on Mercury. While cyanide does not persist in the environment, improper storage, handling and waste management can have severe human health and environmental effects (United Nations Environment Programme, 2012). Cyanide interferes with human respiration at the cellular level and can cause severe and acute effects including rapid breathing, tremors, asphyxiation and death (Lu, 2012). Chronic effects include neuropathological lesions, difficulty breathing, chest pain, nausea, headaches and enlarged thyroid gland (Hinton, Veiga & Beinhoff, 2003b; Agency for Toxic Substances and Disease Registry, 2011b).

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Elemental Hg and MeHg are toxic to the central and peripheral nervous system. The inhalation of Hg vapor can produce harmful effects on the nervous, digestive, and immune systems and the lungs and kidneys and may be fatal (WHO 2007). Children are especially vulnerable and may be exposed directly by eating MeHg-contaminated fish. MeHg bio accumulates in fish and when consumed by pregnant women may lead to neurodevelopmental problems in the developing fetus. Transplacental exposure is the most dangerous because the fetal brain is very sensitive (WHO 2007). Neurological symptoms include mental retardation, seizures, vision and hearing loss, delayed development, language disorders, and memory loss. In children, acrodynia, a syndrome characterized by red and painful extremities, has been reported to result from chronic Hg exposure (WHO 2007, 2008).

Elemental Hg, the form of Hg used in gold amalgamation, is a liquid that volatilizes rapidly (WHO 2007). In humans, elemental Hg is typically measured in blood or urine (WHO 2003, 2008). MeHg, the form of Hg that contaminates fish, is typically measured in blood, cord blood, or hair. Sample collection of hair is the preferred method of biomonitoring for MeHg because it is less invasive than blood sampling. Blood Hg concentrations characterize recent or current exposure (WHO 2008). In populations where exposure to Hg occurs primarily through consumption of contaminated fish, most of the total Hg in the blood is organic and can be used as a measure of MeHg exposure (WHO 2008).

Increased urinary excretion of the enzyme *N*-acetyl-β-d-glucoaminidase (NAG), a biomarker of damage to the proximal tubules of the kidney, was found among occupationally exposed individuals (Drake et al. 2001) as well as among those living in a community where gold mining had been practiced (Tian et al. 2009). Kidney dysfunction was clinically diagnosed in 9 of 103 individuals in a gold mining population in Peru (Yard et al. 2012). Those reporting kidney dysfunction had higher urine total Hg concentrations [geometric mean (GM) = 12.0 μg/g-creatinine] than those not reporting kidney dysfunction (GM = 5.1 μg/g-creatinine; $p < 0.05$). The number of artisanal and small-scale gold miners and the amount of Hg released from ASGM is as great, if not greater, a problem in Asia and Africa as it is in South America (UNEP 2013c).

Harari et al. (2012), Steckling et al. (2011), Tomicic et al. (2011), Paruchuri et al. (2010), Bose-O'Reilly et al. (2008, 2010a), Counter et al. (2006), and Drake et al. (2001) all reported ur The WHO (1991) considers 100 μg Hg/g-creatinine to be the level above which the probability of developing classical neurological signs of Hg intoxication is high. High urinary Hg concentrations were particularly evident among those who amalgamate Hg or heat Hg to remove it from the amalgam. As an example of the elevated urinary concentrations found among small-scale gold mining

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operations, Tomicic et al. (2011) reported that the mean urinary Hg among gold dealers in Burkina Faso was 299.1 µg Hg/g-creatinine. Gold dealers were believed to have the most frequent exposure to Hg vapor. Drake et al. (2001) reported that among self-employed gold miners in Venezuela, the mean urinary Hg concentration was 148 µg Hg/g-creatinine; the high end of the range was 912 µg Hg/g-creatinine. Bose-O'Reilly et al. (2008) reported that the mean urinary Hg concentration among a sample of 80 children working with Hg was 36.50 µg Hg/g-creatinine; the high end of the range was 666.87 µg Hg/g-creatinine. The children who worked in small-scale gold mining operations in Indonesia and Zimbabwe ranged in age from 9 to 17 years. Umbangtalad et al. (2007) found that Thai school children living near, but not working in, small-scale gold mining operations had increased urinary Hg concentrations. Urinary Hg concentrations well above 100 µg Hg/g-creatinine.

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Hair Hg reflects the ingestion of Hg from fish (MeHg) (WHO 1990). The mean hair Hg concentration in virtually all of the 55 studies conducted in ASGM areas or areas affected by ASGM are above the concentration (2.5 µg/g) associated with the WHO's PTWI. Many of the studies reported hair concentrations > 14 µg/g, which the FAO/WHO (2003) considers a no observed effects level (NOEL). The NOEL is based on neurotoxic effects in the fetus; the PTWI was established to protect the fetus from neurotoxic effects (WHO 2007). In 2006, the JECFA concluded that life stages other than the embryo and fetus may be less sensitive to the effects of MeHg. Because of a lack of data on children < 17 years of age, the JECFA concluded that the PTWI should also apply to children (WHO 2007). Hair Hg concentrations above those that reflect the PTWI and NOEL should, therefore, not be indicative of health effects in adults. The WHO (1990) concluded that a hair Hg concentration of 50 µg Hg/g would indicate a low (5%) risk of neurological damage to adults. [e.g., Harada et al. (2001)

and Lebel et al. (1998)], however, suggest that neurological effects may be evident in adults at hair Hg concentrations of < 50 μg Hg/g. Blood concentrations of Hg may reflect exposure to either MeHg or inorganic Hg (WHO 1990, 2003). The background level of Hg in blood for those who do not eat fish is 2 μg Hg/L (WHO 2003).

In spring 2010, Médecins Sans Frontières (MSF) and Nigerian health officials conducting meningitis surveillance in Zamfara State, northwestern Nigeria, recognized an unprecedented outcome of artisanal (subsistence) gold extraction—a deadly outbreak of acute childhood lead poisoning (MSF 2012). They surmised that the outbreak resulted from artisanal processing of lead-rich gold ores, which had recently expanded in scope and become increasingly mechanized through use of gasoline engine-powered flourmills to grind the ores [MSF 2012; United Nations Environment Programme/Office for the Coordination of Humanitarian Affairs (UNEP/OCHA) 2010; von Lindern et al. 2011).

In May 2010, at the request of the Nigerian Government through the U.S. Embassy in Abuja, a CDC emergency response team visited with TG two heavily affected villages, Dareta and Yargalma, to assess and help treat lead poisoning, characterize sources and routes of exposure to lead and other toxicants, and mitigate lead exposures (Dooyema et al. 2012). Using handheld X-ray fluorescence spectrometers (XRF) (Innov-XSystems, Woburn, MA, USA; and Thermo-Scientific Niton, Billerica, MA, USA) [U.S. Environmental Protection Agency (EPA) 2007], Dooyema et al. (2012) measured extreme concentrations of soil lead (often > 100,000 ppm) and soil mercury (up to 4,600 ppm). They found that surviving children < 5 years old had blood lead levels (BLL) up to 370 μg/dL—extraordinary levels given that the CDC recommends BLL be < 5 μg/dL (CDC 2012). Dooyema et al. (2012) also found elevated blood manganese levels up to 41 μg/L, with 66% of samples above their

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cited 7.7–12.1 μg/L reference range. In October–November 2010, CDC and TG field teams assessed 74 additional Zamfara villages (Lo et al. 2012; von Lindern et al. 2011), finding evidence of ore processing and/or lead contamination in more than half the villages and identifying 1,500–2,000 additional children < 5 years old as lead poisoned and in need of treatment. Observations made by and photographs taken by the field teams indicated there were opportunities for exposures to lead and other contaminants in all stages of mining and processing (MSF 2012; von Lindern et al. 2011).

Silica is a mineral found in varying concentrations in ore of the type often mined in the ASGM process. Due to their small diameter and crystalline shape, silica dust particles generated during drilling, mineral extraction, ore crushing, and blasting, can be readily inhaled and deposited in the pulmonary tree (airways). Silica dust is toxic to lung tissue and to the immune system, causing progressive scarring (even after the exposure has stopped) and increased susceptibility to infectious agents in particular, tuberculosis (Rees & Murray, 2007; Gottesfeld, Andrew & Dalhoff, 2015). Silica is also classified as a lung carcinogen (Guha et al., 2011). The presence of other minerals associated with gold deposits, such as iron arsenic sulphide (FeAsS) or lead sulphide (PbS), can be hazardous, as well. Dust generation in the mining process may make these minerals bioavailable to miners and bystanders.

Blasting generates a number of toxic gases such as sulfur dioxide, oxides of nitrogen and carbon monoxide. The use of petrol- or diesel-operated machinery, particularly in confined spaces where adequate ventilation is lacking, is also a major factor in exposure to carbon monoxide, which can cause lethal poisoning (Donoghue, 2004; Agency for Toxic Substances and Disease Registry, 2012). Furthermore, gases such as methane, oxides of nitrogen and others that occur naturally in underground mining

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may displace and reduce oxygen in confined spaces, causing asphyxiation. Although ASGM communities are susceptible to a variety of infections, very common biological hazards affecting them are waterborne and vector-borne diseases, sexually transmitted infections, HIV/AIDs, and tuberculosis. Water and sanitation infrastructure is frequently lacking or inadequate in artisanal and small-scale mining camps because many sites are in remote locations that are hard to reach and the mining is often a transient activity. In some mining areas toilets are rare and pit latrines, if available, are usually shallow and can easily contaminate other water sources (Phillips, Semboja & Shukla, 2001) thus increasing the risk of waterborne diseases such as cholera. Stagnant water provides a favourable environment for reproduction of the mosquitoes that carry diseases such as malaria and dengue (Pommier de Santi et al., 2016). Water contamination associated with ASGM can occur in mines and households in the form of mine waste and chemical discharge (Hentschel, Hruschka & Priester, 2003). The seasonal and migratory nature of ASGM can lead to high-risk behavior that can facilitate the spread of sexually transmitted infections (STIs), HIV and AIDS (Centre for Development Studies: University of Wales, 2004). HIV infection coupled with occupational exposure to silica dust is important risk factors for tuberculosis, particularly among ASGM miners (Rees et al., 2010; Gottesfeld, Andre & Dalhoff, 2015). Biomechanical hazards such as heavy workloads, repetitive tasks, long working hours and unsafe equipment can lead to the development of musculoskeletal disorders, the most common of which are shoulder disorders, fatigue and lower back pain (McPhee, 2004). Physical hazards form a broad category that includes vibration, loud noise, heat and humidity, and radiation, all of which are present in ASGM. Miners experience shoulder disorders as a result of heavy lifting such as overhead work while suspending pipes and cables (Donoghue,

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2004). They also experience chronic injury and fatigue from carrying heavy materials over long distances, and bending over in awkward positions, for example during panning or while digging in cramped spaces (Hinton et al., 2003b). In artisanal gold mining, overexertion results from uncomfortable postures and carrying out repetitive tasks using non-mechanized tools. Accidents caused by the repetitive use of sledgehammers, drills, pickaxes and rock crushers, while minor compared to those caused by power tools and electrical equipment, can result in serious injuries. Often, miners do not realize the extent of injuries resulting from overexertion and thus do not seek medical attention when needed (Hinton, 2006).

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Trauma is a significant concern for miners (Navach et al., 2006). Traumatic injuries associated with ASGM include burns, eye injuries, fractures, impalement, and in some instances physical dismemberment (CalysTagoe et al., 2015; Long et al., 2015). These injuries are often caused by rock falls, explosions and the inappropriate and/or unsafe use of equipment. The latter can not only cause biomechanical injuries but also result in electrical shocks and thermal and electrical burns.

According to Hinton (2006), rock falls are a result of unstable pillars, substandard supports and waste rock being stored next to pits. Reportedly, many artisanal and small-scale miners die in tunnel accidents, under collapsed walls, or in open-pit mines (Hentschel & Hruschka, 2002). In Ghana, Kyeremateng-Amoah & Clarke (2015) found that injuries sustained by ASGM miners arise primarily because of unsafe working conditions and range from minor types such as contusions to severe types such as fractures and spinal cord injuries. The use of explosives can result in exposure to dangerous levels of dust, noise and vibration and lead to asphyxiation and, in some cases, death due to acute traumatic injury (Harari & Harari Freire, 2013). Explosions can also occur when rudimentary tools are used to break up material containing unexploded or misfired explosives (Walle & Jennings, 2001).

Many tasks carried out within the ASGM work process, for example extraction, crushing and milling, are associated with elevated occupational and community noise levels, often to levels that exceed WHO guideline limits for the prevention of hearing loss (Hinton et al., 2003; Eisler, 2003; Green et al., 2015). Noise exposure is associated with the following health outcomes: hearing impairment, hypertension, ischemic heart disease, and stress (Basner et al., 2014; Green et al., 2015). Noise is also associated with sleep disturbance and cognitive impairment as well as social and behavioral effects including annoyance (World Health Organization, 2011). The labor-intensive nature of ASGM can be compounded by extremely hot and humid working conditions. The health effects associated with heat stress are dizziness, faintness, shortness of breath or breathing difficulties, palpitations and excessive thirst (Walle & Jennings, 2001).

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Several studies have cited drug and alcohol abuse as a psychosocial hazard that affects both adult (mostly male) and child miners (Donoghue, 2004; International Labor Organization, 2006). The migratory nature of many people who engage in ASGM is believed to contribute to drug and alcohol abuse which are seen as a ways to cope with difficult circumstances (Hinton et al., 2003b; Thorsen, 2012). Alcohol and drug abuse can lead to violence against partners, co-workers and community members. This has been well described in analogous scenarios, where subsistence work in settings far from home is associated with drug and alcohol abuse and consequent violence (Hinton, 2006). Prostitution is also a factor in some places. However, in many cases violence is not alcohol related and can be associated with stressful working conditions, forced child labor and criminal activities such as

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extortion, theft, sexual violence or intimidation. Where ASGM operations are viewed as illegal, conflicts can lead to an escalation of violence between miners, authorities and local land users.

Food security is an important motivator of ASGM operations which are frequently poverty-driven. Many miners already find it difficult to secure adequate food for their families. Nutritional deficits can be exacerbated in ASGM camps where foodstuffs may be hard to access, for example because of rising costs of local goods and/or deterioration in quality of agricultural lands (Hinton, 2006; Buxton 2013). Changes in availability of disposable income among ASGM communities may also have an impact on quality of diets and therefore on nutritional status. For example, Long et al. (2015a) found that residents of ASGM communities in Ghana reported lower fruit and vegetable consumption and higher sugar and fat consumption than residents of surrounding areas. The latter were reportedly more reliant upon locally grown food items, while the former were thought to consume more packaged foods and foods prepared by local vendors (Long et al., 2015a).

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Again, a study by Hinton (2005) confirms that a number of hazards exist in both surface and underground ASM operations. The study underscores the fact that, although chemical dangers in particular, are associated with mercury and cyanide misuse, most occupational hazards result from poor physical conditions. The study reports that in “1997 alone, 37 of 53 mining-related deaths in Zimbabwe mines were attributed to ground failure, shaft collapses and machinery accidents and in Chinese small coal mines, at least 6000 miners died annually” (Hinton 2002:11).

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2.5 Households Coping Strategies on the Effects of Artisanal Gold Mining

According to a summary prepared by Shelley Taylor in collaboration with the psychological working group in 1998, coping strategies refers to the specific efforts, both behavioral and psychological, that people employ to master, tolerate, reduce, or minimize stressful events. Two coping strategies have been distinguished: problem-solving strategies are efforts to do something active to alleviate stressful circumstances, whereas emotion-focused coping strategies involved efforts to regulate the emotional consequences of stressful or potentially stressful events (Folkman and lazarus, 1980). In artisanal gold mining there is a long-term environmental and health implication.

Chambers and Conway (1992) define a livelihood system as comprising the capabilities, assets (including both material and social resources), and activities required for a means of living. A livelihood strategy connotes a combination of assets and activities to make a living. A livelihood system or strategy encompasses not only activities that generate income but many other kinds of elements, including cultural and social choices (Ellis, 2000).

For Carney (1998), sustainability is achieved when a livelihood "can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base".

Mining communities are also significantly more likely to be affected by health problems, unemployment, trade shocks, famine, or conflict. Thus, the vulnerability of the households in these communities connotes the extent to which the households can adequately resist or withstand shocks. The households' vulnerability is usually influenced by several factors including: (i) Loss of own land or food production or livestock; (ii) Loss.

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Tenkorang and Osei-Kufuor 27 of income and/or tradable assets; (iii) More difficult economic access to food (e.g., due to price increases), and (iv) Breakdown of traditional support systems (FAO/WFP, 2005).

The dominant approach in ameliorating the effects of mining on communities as well as individuals is through monetary compensation, yet this approach has not addressed vulnerabilities of mining communities (Sweeting & Clark, 2000) and mining activities have often led to the alienation of local communities because they lose access to their farmlands and sometimes they are relocated (Aubynn, 2003).

Local people's livelihood priorities and assessments have rarely been incorporated into policy decisions affecting the relevant resources, and this can have serious implications for the relationship between land use patterns and local people, especially if management and land use decisions are based on conventional monetary assessments only (Lawrence & Ambrose-Oji, 2001). Traditionally indigenous people own forestlands and due to their dependence on the land for their livelihoods and subsistence, communities have strong ties to these lands (UNEP, 2002).

The granting of concessional leases for large-scale mining with little or no consultation of local communities has consequences for rural dwellers who engage in farming activities for a living (Yaro, 2010; Awusabo-Asare, Kendie, & Abane, 2000). Furthermore, mining communities are characterized by poor social conditions such as poverty, unemployment, poor housing and infrastructure, prostitution, and poor health as well as the high influx of migrants (Akabzaa & Darimani, 2001). Efforts to address the problems caused in communities affected by mining have usually been the payment of compensation to landowners without regard to tenant farmers, the provision of social amenities, and provision of alternative livelihood training programs or recruitment of locals into menial, low-paying jobs in the mining

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companies. These activities have often been criticized by researchers as not being useful to the beneficiaries as their situations do not improve afterwards (Aubynn, 1997; Aubynn, 2003; Mate, 1998).

The adoption of alternative livelihood strategies is also used by families or households in crisis. Sometimes people gathered firewood in exchange for a cup of rice. Sometimes the price of the firewood was more than the cup of rice but it had to be exchanged to ensure the family had food to eat. Sometimes people looked for menial jobs to do either in their communities or other communities. Another alternative was to skip some meals in the day or to reduce the amount or quality of meals taken to satisfy their need for food. Other alternative activities had been engaging in the production of animals like grass cutters, snails, fish, and to grow mushrooms to supplement the household income. Some of the respondents expressed interest in engaging in these non-traditional farming activities and were willing to be trained in doing it. But for those who were already trained, they complained that they were taught without being given any stock to begin with or any support to start with. Some of the trainees said they were promised that they would be given pigs after their piggery training but only three people received the promised pigs. They were told that after the pigs given to the three trainees produced young ones, the piglets were going to be distributed to the other trainees as stock for their own farms. That was supposed to take two years and they wondered if one had children in school, how long they could wait to even get the stock to begin their farms. Others who were trained in mushroom cultivation suggested that the type of mushroom they were given to plant was not easily marketable. People were even afraid to eat them because they were exotic and local people were aware of the danger of eating unknown mushrooms. The newly trained mushroom farmers had the preconception that the mining company was

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going to buy them for export but that did not happen. This confirms studies done in Ghana in 2009 which showed that the alternative livelihood schemes did not generate sufficient income to replace farming, and was seen as being inappropriate, inadequate, and poorly sequenced which did not restore community independence and individual pride that access to land brought (Temeng & Abew, 2009).

Mining has been a disputed activity that disempowers communities who bear a disproportionate share of the economic, social and environment cost (IIED, 2002). This is exacerbated by the fact the mineral explorations take place in remote, distant areas with poor infrastructure with disputed land tenure rights between government and communities as well as a weakened traditional system and power imbalance between communities and private companies (IIED, 2002; Le Billon, 2001). These diffuse and remote areas lack access to services such as infrastructure, markets, education and resources contributing to keeping the poor in a position where they are unable to participate and benefit from economic opportunities (USAID, 2006). Mining development and concessions have contributed to vulnerability of communities due to misappropriation of land owned by marginalized social groups, power imbalances, poor linkages, environmental degradation and also create restrictions on access to formerly common property resources (IIED, 2002). Ham and Chirwa (2010) argue that resilience of such communities is increased when secure access to resources needed to generate livelihoods is reinforced. Mineral exploitation should also reduce vulnerability and enhance resilience through creating new stocks of capital by enhancing the physical, financial, and human and information resources (Isaacs & Gervasio 2010).

ASM has expanded rapidly in many developing nations driven by increasing population pressure and limited alternative income sources in rural areas (Lahiri-Dutt

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2004). Although it has taken some time, international development institutions now widely agree that ASM is largely a poverty-driven activity (Aryee et al. 2003; Hilson & Banchirigah 2009; Hilson & Garforth 2013). In fact, there is a correlation between the Human Development Index (HDI) of a country and the total proportion of the workforce involved in ASM (Hoadley and Limpitlaw 2004, cited in Yakovleva 2007). Estimates of the number of people involved in ASM worldwide vary dramatically, ranging from 13 million (ILO 2003) to 50 million (Zolnikov 2012). Poverty thus depicted not only by a lack of access properties but also lack of options with reverence to alternative strategies. The poor and most vulnerable households and community are forced to adopt a strategy which enables them to survive but not to improve their well-being (Rakodi 2002:7).

In 2007, the 60th World Health Assembly (WHA) endorsed the "Workers' Health: Global Plan of Action" (WHA 60.26) which encourages countries "to develop and make available specific guidelines for the establishment of appropriate health services and surveillance mechanisms for human and environmental hazards and diseases introduced into local communities where mining, other industrial and agricultural activities have been set up to meet the associated needs of those communities;…".

Training resources for health-care providers that directly address ASGM-related health issues are scarce. However, case studies, toxicology and occupational health literature and publications from governmental and nongovernmental organizations do contain or suggest health components that could be developed further for use. Training sessions specifically for health-care providers were held in two ASGM countries (Indonesia and the United Republic of Tanzania) under the Global Mercury Project (Böse-O'Reilly et al., 2008b) and, in collaboration with WHO, in Mongolia in 2013. The non-governmental organization Artisanal Gold Council has also conducted

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training of health workers in 2012 and 2015 in Burkina Faso and Senegal and has developed information materials on ASGM for health professionals (Richard et al., 2015). WHO has developed a series of training modules to address a range of the environmental and health issues that have an impact on children. Health hazards addressed include mercury, lead, arsenic, radiation and noise (World Health Organization, 2008).

Other training materials are also available that can be adapted by inserting artisanal and small-scale mining content into already evaluated lectures, exercises and activities in the realm of occupational health and safety (Great Lakes Center for Occupational and Environmental Safety and Health, 2005; Workers' Health Education, 2011, World Health Organization, 2001). Therefore, communities and individuals need to adapt various ways to cope with the negative externalities that are emanating from the activities. Most of the time strategies are adopted aiming to deal with and recover from stress and shocks in order to provide sustainable livelihood opportunities for the present and future generations. Most miners simply seek in mining an opportunity within which to counter food insecurity and improve the living standards and livelihoods of their families.

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Over the past two decades, ASM has continued to grow, and today, is one of the most important economic and livelihood activities in Ghana. While Large Scale Mining (LSM) provides a source of employment for an estimated 16,000 people and supports a further 66,000 jobs indirectly (ICMM, 2015), its contribution to labour is dwarfed by ASM, which directly supports over one million people and creates additional employment opportunities for as many as five million more in downstream industries and markets. In 1989, ASM accounted for 2.2 per cent of Ghana's total gold production, yet by 2014 this figure had increased to 35.4 per cent, totalling almost 1.5

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million ounces of gold (Ghana Chamber of Mines, 2014; MinCom, 2015b). In the academic literature this rise is attributed to the largely poverty-driven nature of ASM. It also recognises the wide range of push-and pull factors affecting people's livelihoods and attracting them to the sector, and the trend in recent years of a growing proportion of well-connected, -educated and -financed entrepreneurs entering the sector who see it as a business opportunity (Barry, 1996; ILO, 1999; Hilson and Potter, 2005; Banchirigah, 2006; Hilson and Hilson, 2015). ASM is estimated to employ at least one million people directly and supports four to five million more in associated service industries and markets (UNECA, 2011).The majority of artisanal and small-scale miners (with estimates ranging between 60 and 80 per cent) operate informally, without the security of a licence. It is a predominately rural livelihood activity that often interlocks with and invigorates agricultural activities in virtuous seasonal cycles. Indeed, currently in Ghana there is divergence among academics, policymakers and ASM stakeholders in this regard; with some conceptualising the sector as a largely poverty-driven activity, some seeing it populated solely by businessmen, and others suggesting a mixture of both. As Hilson and Hilson (2015) explore, the policy implications of this divergence are cause for concern. As a wealth of literature now demonstrates, economic reforms implemented across sub-Saharan Africa (as well as in Ghana) during the late 1980s have fuelled a rapid increase in ASM activities over the past two decades. Tens of thousands of people made redundant under structural adjustment, and farmers struggling to cope in liberalised markets, sought immediate economic refuge in the sector; which, due to its low barriers to entry, has provided impoverished communities with a source of regular and relatively well-paid employment and livelihood opportunities (Banchirigah, 2006; Hilson, 2009; Bryceson and Yakovleva, 2010; Hilson, 2013; Hilson and McQuilken,

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2014; Hilson and Hilson, 2015). However, despite the sustained and growing importance of ASM in Ghana — as well as its many positive economic and development characteristics the sector continues to be overshadowed by the negative environmental, health and social impacts associated with its operations.

The ASM sector employs and supports a wide range of people and communities, including families and individuals trying to earn enough to survive, young students funding their school and university education, farmers supplementing their income, and larger groups of men, women, and sometimes, children. Miners undertake diverse roles, from general labouring to skilled machine work, supervising and bookkeeping, and their livelihoods and backgrounds are dynamic and diverse (Gilman, 1999; Hinton, 2005; Fisher, 2007; Hilson, 2010; Maconachie, 2011; Hilson and Hilson, 2015). An established body of literature, and discussions over the course of the research with miners and representatives from the Ministry of Food and Agriculture (MOFA), demonstrate the importance of mining to rural farm livelihoods and mutually beneficial cycles of production (Maconachie and Binns, 2007; Hilson, 2011b; Hilson and Van Bockstael, 2011; Hilson *et al.*, 2013). Artisanal and small-scale mining activities are often intertwined with — and may even entirely support — farming activities in virtuous seasonal cycles, with the higher returns from mining invested in farm inputs such as seeds, fertiliser and equipment. This intertwining and mutual benefit is particularly pronounced in areas with high seasonal variations in rainfall, when periods of too little or too much water to mine coincide with harvests and periods of intense work on the farm. In addition, those who mine their own land now may be more inclined to reclaim and protect it for future agricultural use – using the higher returns from mining activities to learn business skills and earn capital to

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invest in upgrading, thus, being potential agents of change for the formalization of future best practice ASM.

Livelihood diversification into the artisanal mining sector—in rural areas—is generally pursued with the intention of miners, as Hilson described it, 'to branch out into the nonfarm economy because they believe they can earn more money from doing so' (2010:298). Rural livelihood diversification is growing in other parts of sub-Saharan Africa as well as a means of compensating the inability of small-scale farming to sustain livelihoods economically (Maconachie and Binns, 2007; Maconachie and Hilson, 2011) and 'to ensure self-sufficiency for their families' (Banchirigarah and Hilson, 2010:173). Livelihood diversification and the choice to combine seasonal mining and farming activity are nothing new in rural Sierra Leone (Binns, 1982).

As Maconachie and Binns also found, the 'links between the rural and mining economies are crucial to maintaining sustainable livelihoods, and could well play a pivotal role in rebuilding the rural economy' (2007:378). Livelihood diversification is also a common reality in urban centers as individuals seek to diversify and spread economic risks and opportunities (Bolten, 2008; Bürge, 2009; see Maconachie and Binns, 2007 for a discussion of livelihood diversification). Again, due to shared interests, diversification of livelihoods, that is, a diversification also in the relationships people entertain—being a trader, farmer, miner, creditor, carpenter, and so on—the likelihood of more equitable relationships has increased (Maconachie and Binns, 2007; Jønsson and Fold, 2009; Bürge and Peters, 2010). The rise in artisanal gold mining activity has been a result of 'distress-push' diversification, fueled largely by the potential of gold mining as an 'opportunity-driven' activity (Maconachie and Hilson, 2011). Artisanal mining, therefore, presents an interesting alternative in a land

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that offers few opportunities to youth and impoverished rural people. However, in striving to achieve sustainable livelihoods, artisanal mining should not be viewed as an alternative livelihood; much more, it should be recognized and valorized as a complementary livelihood.

Artisanal gold mining has, with the capital that is produced from it, the potential to act as a catalyzing force in reinvigorating small-scale agriculture by bringing it beyond a subsistence state. There is at present already a close relationship between artisanal mining and farming that can complement each other in their seasonal characteristics (Binns and Maconachie, 2005; Maconachie et al., 2006). The seasonality of mining is largely influenced by the costs it incurs during the rainy season, when only 'dry ground' deposits can be profitably exploited by artisanal miners. Other deposits are affected by rising groundwater levels, and pits become filled with water as the rainy season begins in May/June. Pumping water out of these pits consumes a great amount of petrol and money, thus dictating the mining cycle. During the dry season, when farming requires much less work, many individuals engage in mining activities. However, in-depth stakeholder interviews with artisanal miners in the Kangari Hills area have revealed that seasonality and the links between agriculture and mining are far more complex. For some artisanal gold miners, agriculture actually complements the activities of the mining cycle, when mining is not feasible due to the high costs of mining in the rainy season.

Beyond the mere fact that farmers are mining and miners are also farming, that is, their seasonal shift in occupation, there are further instances of dovetailing of mining activities with the local farming sector, which have to be augmented to foster more sustainable livelihoods. Mining areas increase the demand for consumer goods, first

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and foremost for foodstuff, which can be satisfied by local agricultural production (see Riddell, 1974; Rosen, 1974; Richards, 1996; Maconachie and Binns, 2007).

The phenomenon of rural livelihood diversification has long been recognized by policy makers, particularly in sub-Saharan Africa largely because of the growing vulnerabilities of its rural populations (Hilson et al., 2013). While livelihoods in rural sub-Saharan Africa and Ghana in particular is known to be heavily dependent on farming activities, it is also a known fact that these activities are peasantry in nature and therefore bedeviled with the drudgery and low productivity associated with peasant agricultural practices (Andoh, 2010; Andoh & Bosiakoh, 2010). The use of ALPs as a tool for addressing the spread of illegal artisanal and small scale mining has long been articulated but how effective these have been is a matter yet to be understood. This section explores this issue further and attempt to highlight critical concerns that ought to be taken into consideration if ALPs are to be seen as necessary interventions for dealing with poverty in rural mining communities. Suffice to note at this point that Carson et al. (2005) and Hilson and Banchirigah (2009) have expressed skepticism about ALPs as a tool for dis-incentivizing participation in artisanal and small scale mining among rural community dwellers. However, the case for implementing ALPs has long been made by policymakers and accepted by many, including large scale mining companies (Hilson and Banchirigah, 2009) although its impact can best be described as mixed. It is the view of Banchirigah and Hilson (2009) that ALPs have become popular in sub-Saharan African countries where ASM activities have become pronounced as a result of low returns in traditional agricultural production. They stress that the inability of states in these countries to support small-holder farming activities have pushed many small-holder farmers into illegal ASM, which is popularly known as galamsey in Ghana. Thus, ALPs in the form of agrarian

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oriented activities have often been lauded as a strategy for addressing the challenges associated with the spread of illegal ASM but these have been critiqued by Banchirigah and Hilson (2009) as ineffective in addressing the problems of ASM. On the other hand, the critique has more to do with the manner in which ALPs are introduced than with the rationale behind ALPs. Alternative Livelihood Project (ALP) refers to interventions aimed at reducing the prevalence of an activity or activities that are deemed to have damaging environmental consequences on the lives of people by substituting such activity or activities with those that are less damaging (Wright et al., 2015).

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The adverse environmental and social impacts of mining in sub-Saharan Africa are well documented (Davidson, 1993; United Nations (UN), 1996; International Labour Organisation (ILO), 1999; Kitula, 2006; Fisher, 2007). In hana in particular, the industry has experienced unprecedented growth in recent years, bringing with it many problems that the authorities have struggled to address (Amankwah & Anim-Sackey, 2003; Hilson & Porter, 2005). Mining has generally been noted to account for changes in both the physical landscape and natural resources hence affecting the daily lives of people living in mining areas (Aryee, 2001). In fact, the argument of whether mining is indeed a panacea to economic problems on most mining communities have been deeply questioned (Aryee, 2001).Problems that emanate from such situations are compounded by wrong signals eternal wealth which is sent to the populations of other settlements who troop to the mining centers in search of the non-existing wealth (Hilson & akovleva, 2007). This increases the population of the mining centers substantially without any improvement in the means of livelihoods but instead, deterioration. Mining takes a large share of the land area of the inhabitants of the mining areas. These lands are usually the fertile ones relied on by the residents

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(Aryee, 2001). In Ghana, for instance, by 2006, 13.1% of the country's land area was under concession to mining and mining explorations companies (Ghana Chamber of Mines, 2006). In areas such as Tarkwa, as much as 70% of the total land area is under concession mining and two thirds of the entire Wassa West District (Ghana Chamber of Mines, 2006). This result in community dislocations and the taking away of arable lands as most of these mining centers in Ghana have their traditional economic activities as farming. An account is given a recent time in Ahafo South where 9500 subsistence farmers where displaced (Planning Alliance, 2005).

In Tanzania, 400,000 people were evicted in one community alone to allow for the development of a large- scale gold mine project (Curtis & Lissu, 2008). A further deprivation of the residents of their livelihoods is the pollution of water bodies, the felling of trees, dust and other mining chemicals that have long term health implications for them. The aggregated effects of these are that the residents are indeed worse off with mining than before by making them very vulnerable (Aryee, 2005). However, it is clear that mining greatly deprives the people of mining societies of their livelihoods and that the profits cannot make for the huge losses hereafter such mining corporations/individuals need to provide an incorporated means of alternative livelihood to the residents or better still assist households to develop alternative livelihoods themselves for sustainability.

The various effects of mining on the lives of residents in mining centers, have led to a unified voice calling for a more responsible approach on the part of the mining companies and their national governments to provide the residents with dignified means of sustaining themselves (Banchirigah, 2008). Mining companies around the world and national governments started to plan alternative livelihood programs for the people in mining areas. The main objective of alternative livelihood programs has

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stayed to ensure the enhancement of standard of living of people through providing them with alternative income sources. Greatest of the alternative livelihood programs have accepted methodologies that are economic in position. This approach is by extreme the most trailed and visible in different formulae. It ranges from the legalization of artisanal mining, training in traditional skills, and alternative farming approaches. With all these methodologies, instances drained from different parts of the world show mix outcomes.

In Bolivia, an approach that has been much mentioned is the economic approach; residents of mining communities have been trained on alternative economic activities such as new and improved farming methods (Banchirigah, 2008). This was frequently accompanied by providing start-up incomes, fertilizers and insecticides for their farms and Markets to their farm yields are provided for by various advertising groups designed by mining corporations and provided with capital to purchase such produce and carriage them to near market centers. Storage facilities were also provided to help save circumstances where there was extra supply of farm products. Also, the same approach was embraced in Tanzania where residents are trained in animal rearing such as sheep, goats, and grass cutter among others as alternative livelihoods (Curtis & Lissu, 2008). Administrative centers were formed to distinctly cater for such investment issues. Recommendations are primary given to the residents before training them and later offering them monetary assistance to invest these ventures. The method in Uganda, which is an emerging gold mining nation in Africa, has not been diverse. The promotion of native traditional crafts and the training of the people to take lead of the emerging tourism trade in such societies have been the schedule of such alternative livelihood method in Bolivia.

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Various studies identified alternative strategies that households and communities have adopted to deal with their lives. Ontoyin and Agyeman (2014) study on the effects of small scale mining on mining communities in the Talensi-Nabdam district of northern Ghana have note the negative effects of such mining activities that hits rural folks hardest because it directly affects their livelihoods through decrease in their agricultural activities thus denies them of their farmlands, decrease in fishing activities such as water pollution, decrease in Shea-nut gathering activities, and almost abolishing hunting and firewood harvesting which life depends on. They though detected that the people adapted to these altering situations by resorting to trading activities, reclamation of lands and animal rearing for their livelihood. They thus make a case for the implementation of alternative livelihood programs in mining communities. In order to have safe and secure livelihoods, households need to have access to portfolio of assets or capitals both tangible - cash, land, physical or skills and intangible claims on the other and the government and access rights, for earning land, to form cooperation's, unions and to develop mutual understanding and networks. The strategy open to households depends on the assets owned or held and the ability to find and make use of livelihood opportunities (DFID 1999).

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These strategies have highest potential to be ineffective and inefficient in the long term, if consumption decline and or assets are lost permanently or if successive entitlements on particular strategies deplete the natural resource or financial resources base on which households, individuals and communities depend. Poverty thus portrayed not only by a lack of access assets but also lack of options with respect to alternative strategies. The poor and most vulnerable households and community are forced to adopt a strategy which enables them to survive but not to improve their well-being (Rakodi 2002:7).

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In the specific case of mining communities in Ghana, there is a general understanding that mining alone cannot absorb all available labor force in the communities and hence there is the need to create and support other forms of economic activities that can complement existing ones. It is this understanding that has informed the development of Alternative Livelihood Projects, also known as Local Economic Development Projects (LEDP). Thus ALPs are used as economic instruments to create opportunities for local economic development outside of mining and to discourage engagement in illegal artisanal and small scale mining activities among the youth in resource communities. Views on the ability of ALPs to reduce participation and spread of ASM in Ghana are varied and can best be described as 'mixed'. While state officials perceive AL projects as holding the key to addressing the challenge of ASM and poverty reduction, particularly in mining districts, others are skeptical about the ability of ALPs to minimize participation in ASM (Carson et al., 2005, Hilson and Banchirigah, 2009) because of the strong economic incentives for engaging in ASM. An assessment of some ALPs in Ghana by Hilson and Banchirigah (2014) showed that the people for whom the AL projects were designed showed very little interest in them.

Another study by Tschakert (2009) among miners in Dunkwa area of the Central Region of Ghana showed very little interest in the AL projects like snail cultivation, grass-cutter rearing, and snail cultivation. In another study, Tschakert (2008) takes a different approach to the ASM debate and notes that the devaluation, misrepresentation and criminalization of ASM tend to keep ASM operatives from policy decisions relating to potential alternative livelihoods. The author concludes that to the extent that illegal ASMs look forward to formalizing their mining activities, they are less likely to commit to what seems to be short-lived alternative livelihood

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strategies introduced from without because the promoters or implementers do not follow it through to the end. And this tends to demotivate and dwindles the interest of these operators of the illegal mining business to quit pursuing the ALPs implemented. Thus, instead of criminalizing illegal ASMs, it is best to assist them to become more environmentally conscious and recognized as useful citizens. Illegal ASMs – described as 'Galamsey' miners in Ghana – are often regarded as 'threat', 'problem', 'headache', 'challenge' and 'menace' (Palmer and Sackey, 2004; Ryan, 2006; Tschakert, 2008) and counters the new policy to formalize ASMs because of their potential for poverty reduction in rural communities. In fact, the state benefits directly from ASMs because it 'officially purchases galamsey gold through licensed agents of the Precious Minerals Marketing Company (Tschakert, 2008:25).

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Lufwanyama communities obtain timber and non-timber forest products (NTFPs) such as fruits, vegetables and medicinal plants from forests to earn an income and supplement their diets (Shulumi, 2002; Choongo, 2004). Being a restricted area and under paramilitary guard means access is by permit and without its trespassing. Mining concessions are not enhancing access to forest resources which contributes 20% of household incomes in rural areas (Bishop et al. 2008 as quoted in Ham and Chirwa 2010). Women are sometimes are allowed to collect NTFPs since they are food providers while men on the other hand, are victims because they are suspected to be illegal miners. As a result, calls by Chief Lumpuma's at his annual *amafulo* visit 2012, to increase access by mines to allow local people passage through the area and requests for surveys to determine exact location of emeralds so that new land uses can be devised.

According UNEP (2006) literacy affects the type of information one accesses, the opportunities available and their livelihood choices. Quality education and improved literacy are essential if local people are to compete for jobs, enhance their skills, contribute to the national economy as well as protect their environment to enhance inter-generational equity.

Lufwanyama district is a vast rural area and has no water reticulation system hence no piped water and solid waste disposal systems (Choongo, 2004). Water is vital for survival and clean fresh water is essential for a healthy life. UNDP (2011), states that access to adequate and clean water for consumption is essential to obtain a healthy life while appropriate sanitation prevents diseases assures dignity to individuals in Zambia. Water sources include boreholes, shallow wells and pits and rivers. The degree of water pollution has very severe consequences for local communities, including those served with piped water, increasing the cost of chemical treatment to make such water potable (CSIR – Water Research Institute, 2013).

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2.6 Conceptual Framework

The conceptual framework (Figure 2.1) displays the effect of mining on the environment and the health of people. This is centered on the assessment of the existing works. Mining procedures on the land can also be concealed or outward mining. With these techniques, there are environmental and health effects. The effect of mining undertakings on the environment is actually extraordinary. Mining accomplishments necessitate attainment of enormous zones of plots. Deep and surface mining destroy the land meanwhile there is demolition of the whole forestry, land for agricultural and other purposes are misplaced. Quite apart, discharges of chemical elements (cyanide, mercury) and toxic resources into the close rivers after water contamination, abolishing water forms and aquatic lifecycle. Contacts of such chemical elements are unsafe to human healthiness. Numerous health inferences are

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linked with mining accomplishments. Mining happenings, such as blasting of rocks principal to air and noise Effluence, can disturb the folks in the near regions. These occasionally lead to the manifestation of greater respiratory infections (cancer, cough or cold, asthma). There is prevalence of malaria, diarrhea, severe conjunctivitis besides accidents entirely of which end result in morbidity and mortality in the mining zones. In reaction to the impacts, mining firms typically pursue to lay despondent health actions by providing health facilities that is hospitals/clinics, health sensitization of different forms to handle the health problems of the local folks around the mining areas.

Base on the literature that was studied, the environmental and health cost and damages of mining undertakings far overshadow their financial and societal aids therefore, great health cost gained as a consequence of mining actions. Nevertheless, the harmful environmental and health impacts of mining activities are so enormous that cries for critical mediations.

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2.7 Conceptual Framework

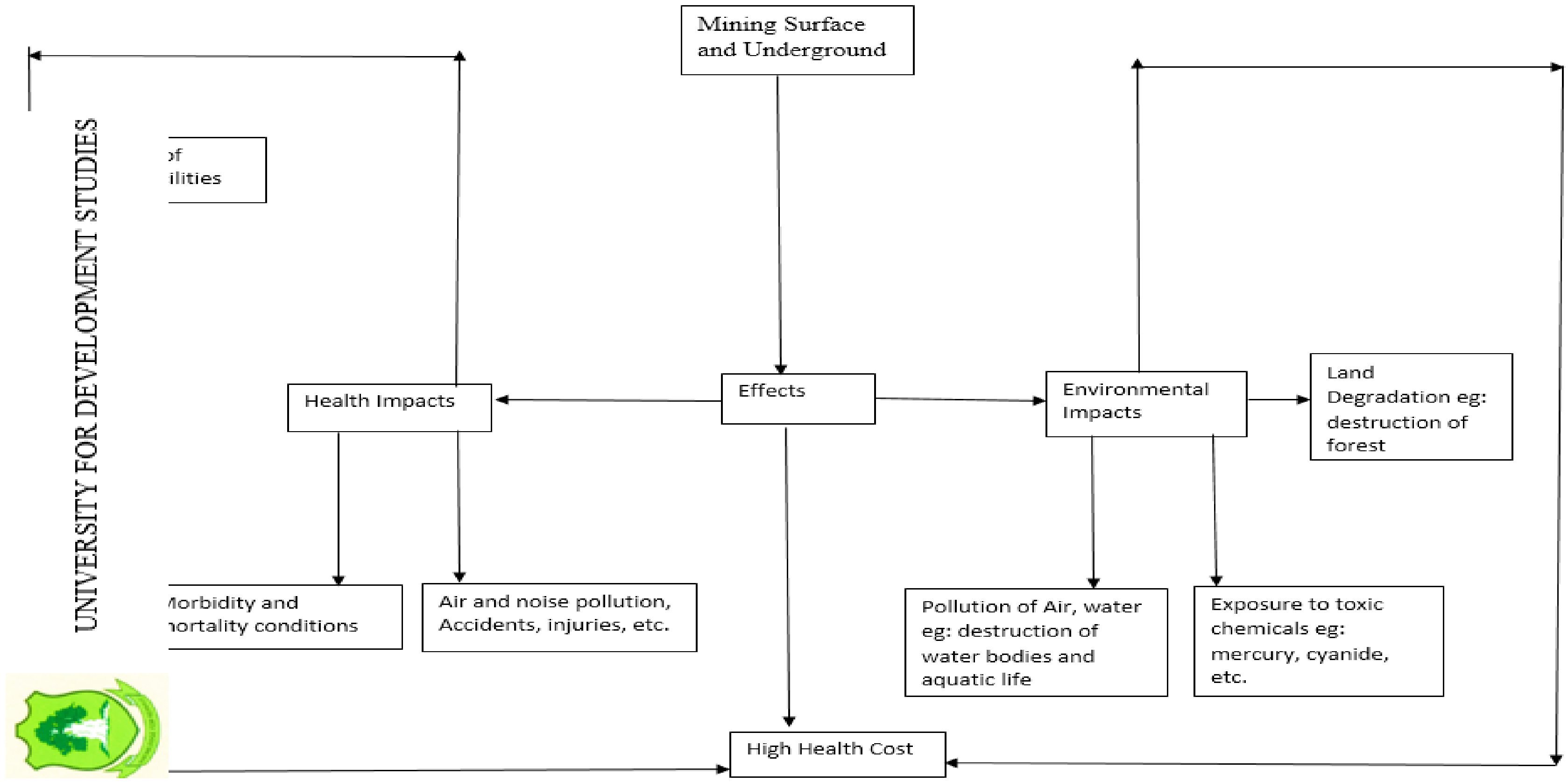

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Figure 2.1: Mining Environment and Health

Source: Yeboah,(2008)

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CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Introduction

This chapter discusses the methodological procedures that were employed in the study. These procedures are structured along the following major steps; the study area, research design, target population, sample and sampling procedures, sources of data, instruments and data collection

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3.2 Procedures and Data Analysis

3.2.1 Profile of the Study Area

The Builsa North District is one of the thirteen administrative districts in the Upper East Region of Ghana. The Builsa North District was carved out of the Builsa South District on 15th March, 2012 by an Act of Parliament, 1993 (Act 462) with Sandema as its administrative capital. The paramount aim of creating this Assembly is to bring the business of governance to the doorsteps of the ordinary Ghanaian.

The Builsa North District has a total population of 56,477 with 98 communities. The district lies between longitudes 10 05""West and 10 35"" West and latitudes 100 20"" North. The Builsa North District shares boundaries with Kassena–Nankana West District to the North, to the West with Sissala East District, to the East with Kassena–Nankana East Municipal and to the south with Builsa South District. The district covers an estimated land area of 816.44030 km2. (GSS, 2010)

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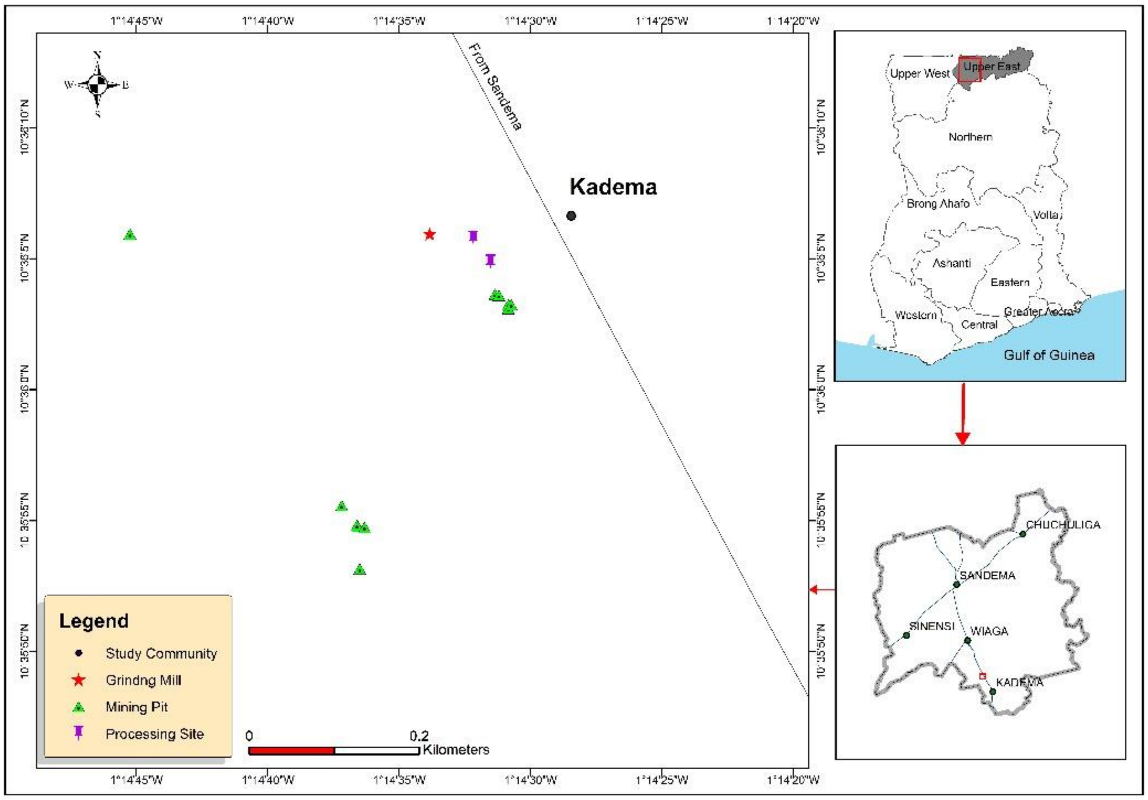

Figure 3.1: Map of Study Area

Source; Author's Construct, 2017

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The topography of the area is undulating and slopes ranging from 200 meters to 300 meters within the western and northern part of the district particularly around Bachonsa and Chuchuliga zones. In the valleys of Sissili, Kulpawn, Besibeli, Tono, Asibelika and the Azimzim, the slopes are gentler and range from 150 meters to 200 meters.

The district has mean monthly temperatures ranging between 21.90 C and 34.10 C. The highest temperatures are recorded in March and this can rise to 450 C, whereas the lowest temperatures are recorded in January. The dry season is characterized by dry Harmattan winds.

There is only one rainy season, which builds up gradually from little rains in April to a maximum in August-September, and then declines sharply coming to a complete halt in mid-October when the dry season sets in.

The district is characterized by Savannah woodland and consists mostly of deciduous, widely spaced fire and drought resistant trees of varying sizes and density with dispersed perennial grasses and associated herbs. Through the activities of man, the woodland savannah has been reduced to open parkland where only trees of economic value like baobab, acacia, sheanut and the dawadawa have been retained with time (GSS, 2010).

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3.2.2 Population

The population of the Builsa North District according to the 2010 Population and Housing Census is 56,477 representing 5.4 percent of the region"s total population. Females constitute 50.8 percent and males represent 49.2 percent. About ninety percent (89.2%) of the population is rural. The District has a sex ratio of 96.9. The population of the District is youthful (13.8%) of the 5-9 age groups, depicting a broad base population pyramid which tapers off with a small number of the 70 plus years (5.5%). The total age dependency ratio for the District is 88.0, the age dependency ratio for males is higher (91.0) than that of females (85.2) (GSS, 2010).

3.2.3 Economy

Builsa North District is predominantly rural with agriculture as the main economic activity undertaken by self-employed farmers. The Builsa District North possesses some of the best spots for tourist attraction. They include the Sissili Central forest reserves with an area of 155.09sq km, Abuga Crocodile pond in Uwasi, the Fiisa

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Shrine and the Doninga Slave Market. More than seven out of ten (71.9%) of the population aged 15 years and older are economically active. Of the economically active population, 96.8 percent are employed while 3.2 percent are unemployed. For those who are economically not active, a larger percentage of them are students (44.5%), 27.5 percent perform household duties and 6.6 percent are disabled or too sick to work. More than half (55.8%) of the unemployed are seeking work for the first time. Of the employed population, about 69.8 percent are engaged as skilled agricultural, forestry and fishery workers, 10.2 percent in service and sales, 8.7 percent in craft and related trades workers, only 6.2 percent engaged as managers, professionals and Technicians. Of the population 15 years and older, 65.4 percent are self-employed without employees, 20.4 percent are contributing family workers, 1.3 percent are casual workers. Only 0.7 percent are domestic employees (house helps). Overall, men constitute the highest proportion in each employment category except contributing family worker, apprentice and domestic employee. The private informal sector is the largest employer in the District, employing 91.6 percent of the population followed by the public/government with 6.8 percent (GSS, 2010)

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3.3 Methodology

3.3.1 Research design

The research approach that was adopted for the study is a mixed method. It combined elements from two social science perspectives (positivist and interpretative social science). The study also adopted a descriptive and explorative study design. It was descriptive because the study involved a systematic collection and presentation of data which gave a clear understanding of artisanal mining and its impacts on the environment and health. Researchers explore when they have little or no scientific

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knowledge about the group, process, activity or situation they want to examine but have reasons to believe it contain elements worth discovering, describing and evaluating (Babbie, 2004).

The main goal for using the exploratory study design in this study was to facilitate data collection and to produce inductively derived inferences about the peculiar artisanal mining and its implication on the environment and health in the district. To effectively explore and address the objectives of the research, the study approach was based on two special orientations, namely flexibility in looking for data and open-mindedness about where to find data to answer the research questions.

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3.3.2 Target Population

The target population for the study was household heads and opinion leaders such as chiefs, landlords or tindanas, and the artisanal miners. The choice of population was based on the fact that opinion leaders are mostly in control and they determine or prescribe the procedures one would need to follow to own and use land and the households are those who are affected by the artisanal mining.

3.3.3 Sources of Data

Data was obtained from primary and secondary sources. The primary data was generated from fieldwork. Primary data constituted general background characteristics of respondents, their household resources, their livelihood strategies and problems associated with the activities of the illegal mining, etc. The secondary sources of data which include journals, publications, articles and the internet were employed to provide a deeper understanding of the key concepts, components and issues related to the subject under study.

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3.3.4 Sample Size and Sampling Techniques

According to Amedahe and Gyimah (2002), sampling refers to the process of selecting a portion of the population to represent the entire population. Selection of communities was done using the purposive quota sampling technique because quotas were taken from each of the communities in the district. Two communities in the district were purposively chosen because of the fact that they are the communities where illegal mining is taking place, which are the Bachonsa and Chansa. As noted by Lincoln and Guba (1985), purposeful sampling aims at maximizing information collection for variance and, as confirmed by (Patton, 1990), it identifies information-rich sources for in-depth data collection. Purposive sampling was used to select the officials from the district assembly and health centers from the communities selected. This was because the researcher targeted particular individuals in the study (Greenstein, 2003). Those categories of individuals were selected because they are believed to possess in-depth knowledge of the topic being studied. This technique was adopted because the study units from these categories were relevant for the study and may be left out if probability sampling was used. The sample size of households was determined by the Cochran's (1977) sample size estimation formula given as:

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$$n_0 = \frac{t^2 \times (p)(q)}{d^2}$$

Where, n_o is the uncorrected sample size;

t is the t-value for the selected margin of error;

p is the population proportion;

q is 1 – *p;* and

d is the acceptable margin of error for the sample size being estimated. The study adopted a margin of error (*d*) of 0.05, which indicates the level of risk the study

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is willing to take that true margin of error may exceed the acceptable margin of error. The chosen (*d*) corresponds to a t-value (*t*) of 1.96. The variable used for the population proportions was households. However, these proportions were not known. Upon Bartlett et al.'s (2001) recommendation, the study also adopted a *p* of 0.5 and a *q* of 0.5. This provided the largest sample size possible to cater for possible non-responses. An approximated figure of 384 was calculated for n_0.

However, the population must be corrected for the 0.05 or 5 percent margin of error using Cochran's (1977) correction formula, which is given as:

$$n_1 = \frac{n_0}{1 + \left(\frac{n_0}{P}\right)}$$

Where, n_1 is the required corrected return sample size;

n_o is 450; and

P is the population size (267).

The formula generates an approximated sample size of 150. But for the purpose of this study, this was proportionately divided among the two communities and an approximated total of 160 were therefore sampled. In total the sample size for the study was made up of the 98 artisanal miners, 58 households, 1 health worker, 3 assembly officials, giving a sum of 160. This method ensured proportional selection of respondents from the departments as well as reduced biases. Households and some key informants were purposively sampled for the study. The main objective was to produce a sample that was logically assumed to be representative of the population. This was accomplished by applied expert knowledge of the population to select in a non-random manner a sample of the elements that represent a cross-section of the population. It was therefore necessary to apply subjective method to decide which element to include in the sample especially with regards to the two communities.

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On the other hand, the accidental sampling was used to select the artisanal miners. The sample was haphazardly gathered by interviewing the first 98 people the researcher runned into in the mining community who were of the sound mind and willing to talk.

3.3.5 Data Collection Instruments and Methods

The main instruments for primary data collection were questionnaires, interview schedules and in-depth interview guides. These tools were employed to facilitate the data collection process as and when the use of any one of them becomes necessary and to ensure a complete assessment and understanding of the phenomenon under investigation.

Three sets of instruments were designed. The first questionnaire, self-administered to literate household heads. The interview schedules were administered to illiterate household heads. Combinations of close and open-ended questions were formulated to effectively secure data and solicit for the views and opinions of the respondents. Questionnaires and interview schedules took into consideration issues including biographic and socio-economic characteristics of respondents in the study area.

Data collection instruments were pre-tested in the Talensi District where there is illegal mining and the district also shared similar demographic, economic and social characteristic with the study area. Results of the pre-test were to inform the level of appropriateness of instruments and ensured accuracy of instruments. Primary data was collected by the researcher and five field assistants were recruited and trained to assist in the data collection exercise. Mode of recruitment was based on fluency in spoken and written English, and Buli, legibility of hand writing and ability to transcribe from English into the local dialect of respondents and vice versa. The training was to

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ensure equal understanding and interpretation of questions, appropriateness and completeness in recording responses.

3.3.6 Data Analysis and Presentation

Data obtained from the fieldwork was edited. The analysis processes followed a structured format comprising coding and developing a frame of analysis and finally the actual analysis. These steps were followed to ensure that the data was properly cleaned and to ensure quality results. Templates for the questionnaires and interview schedules were laid using the Statistical Package for Social Sciences (SPSS) software version 16. The analysis was in two sections; the socio-demographic characteristics of the respondents and the main issues that involved artisanal mining and its implications on the environment and health. Frequency distribution and other descriptive statistics were used to describe the data, summarizing and finding percentages in order to draw inferences, deductions and conclusions. Chi square analysis was also used to ascertain if association existed between the variables.

Qualitative analysis employing basic descriptive statistics was undertaken to examine the nature of artisanal mining in the district. Sarantakos (2005) indicates that in qualitative analysis, personal choices, decisions and preferences as well as subjective views about truths and knowledge constitute the foundation for inquiry. In view of this, the researcher used the qualitative analytical procedure to examine the views of the opinion leaders on the nature and impact of artisanal mining in the district.

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3.4 Water Quality Testing

Samples of water were drawn from a water source in the mining area and taken to the Council for Scientific and Industrial Research (CSIR), Water Research Institute (WRI) at the water quality laboratory for testing in Tamale, Northern Region. Parameters tested included, conductivity, colour (apparent), turbidity and Ph.

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CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 Introduction

The chapter presents the information collected from the field and their interpretations. The chapter highlights on the social and demographic characteristics (ethnicity, sex, age, marital status, education, religion and occupation) of the respondents. Also, other responses that were collected from the field were in relation to the environmental and health impacts of mining operations as well as mining processes and households' coping strategies. The gathered data are presented in different themes to reflect the objectives of the study.

4.2 Socio-Demographic Characteristics of Respondents

Socio-demographic characteristics of respondents are very important for studies of this nature since they influence respondents' perceptions, attitudes, beliefs, views, and opinions. The socio-demographic characteristics captured here are sex, age, and marital status, level of education, religion, and occupation of respondents.

A total of 98 respondents (miners) were interviewed to ascertain whether they are indigenes or non-indigenes in the study communities. The highest frequency 62 (63.3%) was recorded for those who answered "indigenes" and the lowest frequency 36 (36.7%) was recorded for those who answered "non- indigenes". From Table 4.1, a total of 54 respondents (household heads) interviewed were indigenes of the study community thereby giving a 100% representation.

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Table 4.1: Ethnicity of Miners

Ethnicity	**Frequency**	**Percent**
Indigene	62	63.3
Non-indigene	36	36.7
Total	98	100

Source: Field survey, 2017

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From Table 4.2, of the 98 artisanal miners (respondents) who were interviewed in relation to gender distribution, a frequency of 68 representing 69.4%) were males whereas the remaining frequency 30, representing 30.6%) were females. Ironically, the population of Ghana shows that women are 51% more than men but when it comes to decision-making in society women views are not taken into consideration. Therefore women are not adequately represented and this translates into the mining sector where women do not have equitable access to profitable areas of the mines. This kind of gender combination was deliberately and strategically done to get a balanced view regarding the implication of artisanal small scale mining on the environmental and health in the Builsa North District. This means that views obtained from both the female and the male respondents suggest the different perception each group has on the issue under study. Also a total of 54 households were interviewed to solicit views on how these households were coping with the implications of the activity in the landscape. Males had a representation of 36 (66.7%) and females 18 (33.3%).

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Table 4.2: Sex Distribution of Miners Respondent

Gender	**Frequency**	**Percent**
Male	68	69.4
Female	30	30.6
Total	98	100

Source; Author's Construct, 2017

From Figure 4.1, The total respondents for the study was 156 including miners from the target group, between the ages of 10 -19 represented a frequency of 19(19.4%) miners, 20-29 got a frequency of 53 representing 54.1%, 30-39 also had a frequency of 28 which also represents 28.6%, 40-49 and 50-59 had a frequency and percentage of 6(6.1%) and 1((1%) respectively while 60-69 got a zero representation. It is important to solicit views from different age group so as to obtain balance perspectives from both the aged and the young. Also, age composition matters in this research since people of different ages have different perceptions about the phenomena under investigation hence there was the need to solicit data from different age categories.

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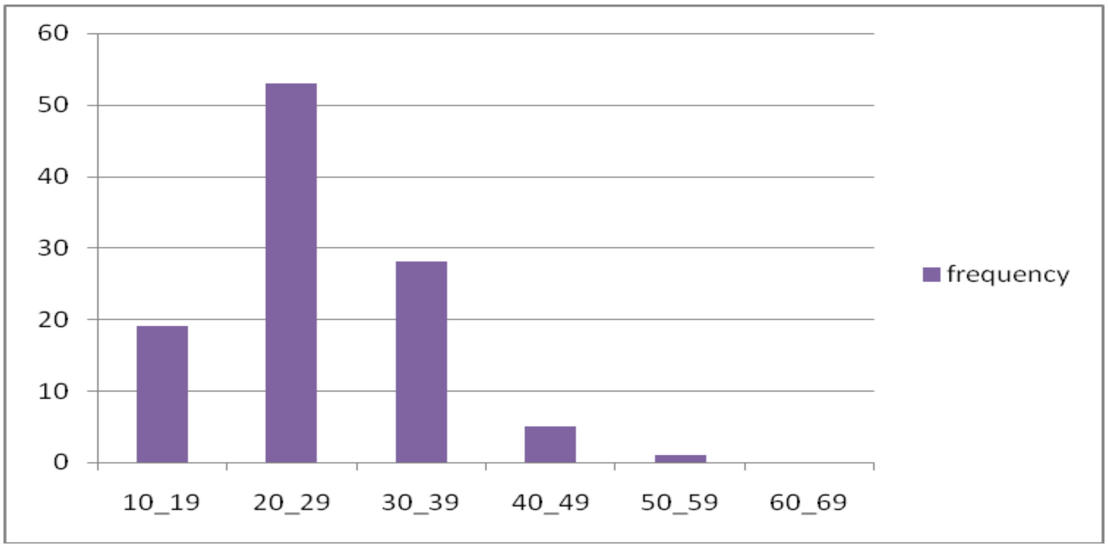

Figure 4.1: Age Category of Miners (Respondent)

Source: Field survey, 2017

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Apart from the artisanal miners that were interviewed, household's heads were also a target group that was interviewed. This was done to ascertain/inform on their knowledge on artisanal gold mining and how it has impacted their lives as well as their coping strategies to manage the menace. Age category of HH heads ranges from 20-29 representing 16.7%, 30-39(25%), 40-49(48.1), 50-59 and 60-69 representing 5.6% and 3.7% respectively (see Figure 4.2).

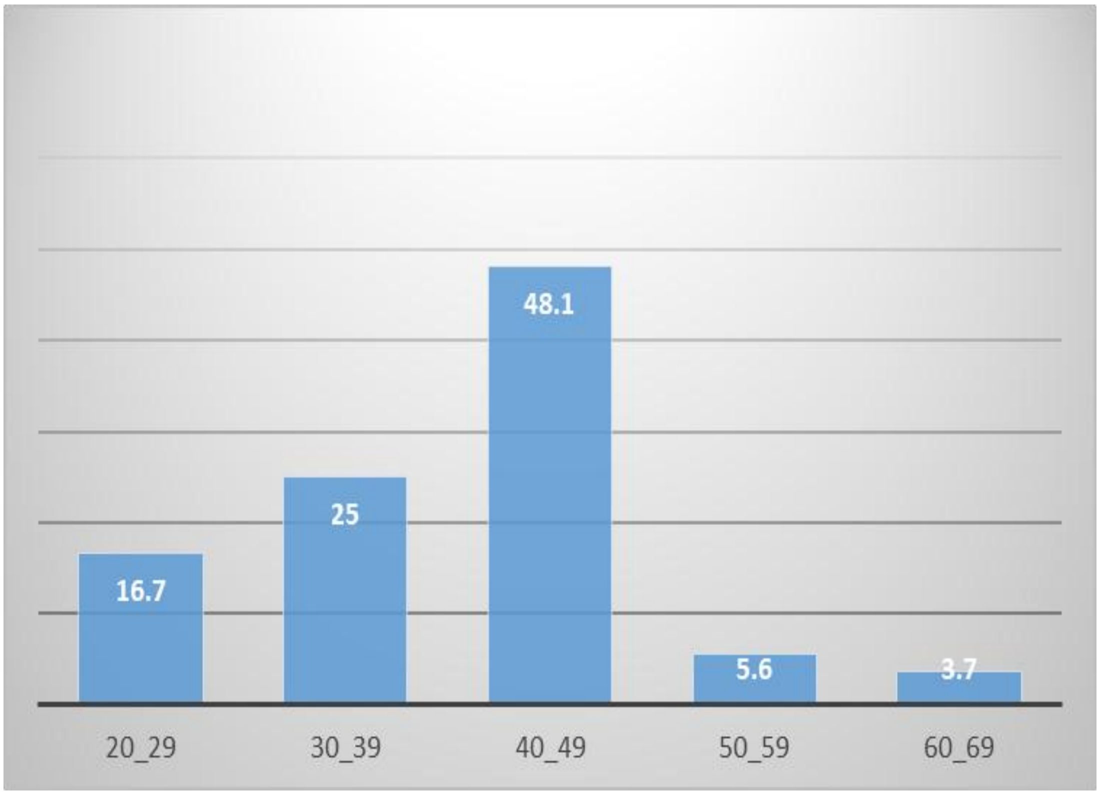

Figure 4.2: Age Category of Households Head

Source: Field survey, 2017

From the study, a total of 54 HH respondents were interviewed. The highest frequency 12(22.2%) was recorded for households with 5 members followed by 11 (20.4%) which was recorded for households of 4 members. Also, 8(14.7%) and 7 (13.0%) represented households of 7 and 8 members respectively. However, 6(11.1%), 4(7.4%) and 3 (5.5%) represented households with 6, 4, 3 members respectively. The lowest frequency of 1 (1.9%) has equal representation for the largest household size of 10, 12, and 19 (See Table 4.3).

Table 4.3: Family size of HH

HH	**Frequency**	**Percent**
3	3	5.5
4	11	20.4
5	12	22.2
6	6	11.1
7	8	14.7
8	7	13.0
9	4	7.4
10	1	1.9
12	1	1.9
19	1	1.9
Total	54	100.0

Source: Field survey, 2017

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From the Table 4.4, the study analyzed the level of education of respondents and the outcome is as follows; out of the 98 respondents comprising of miners, a frequency of 53, representing 54.1% had basic/primary education which is the highest frequency, 28 respondents, representing 28.6% had no form of education while (10.1%) and (7.1%) representing 10 and 7 respondents also had middle/JHS and secondary/SHS/Voc. education respectively. The research considered people with different educational backgrounds in order to have a divergent views of the implication of mining on the environment and health. People with different educational backgrounds have different levels of appreciation of issues and can present issues differently. All these divergent views must be considered for proper understanding of the health implications of the activity.

Quite apart, household's heads who were also interviewed in other to obtain relevant information on the activity and how it is being managed, it also seek to identify some coping strategies that are practiced in the communities. From Figure 4.3, household heads who did not obtain any form of education had a 29% representation, basic/primary level represented 38.9%, and while middle/JHS 22.2% and secondary/SHS and tertiary had 3.7% and 5.6% respectively (see Figure 4.3)

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Table 4.4: Educational level of Miners (Respondents)

Educational level	**Frequency**	**Percent**
None	28	28.6
Basic	53	54.1
Middle/JHS	10	10.2
Secondary/SHS/Voc.	7	7.1
Total	98	100

Source: Field survey, 2017

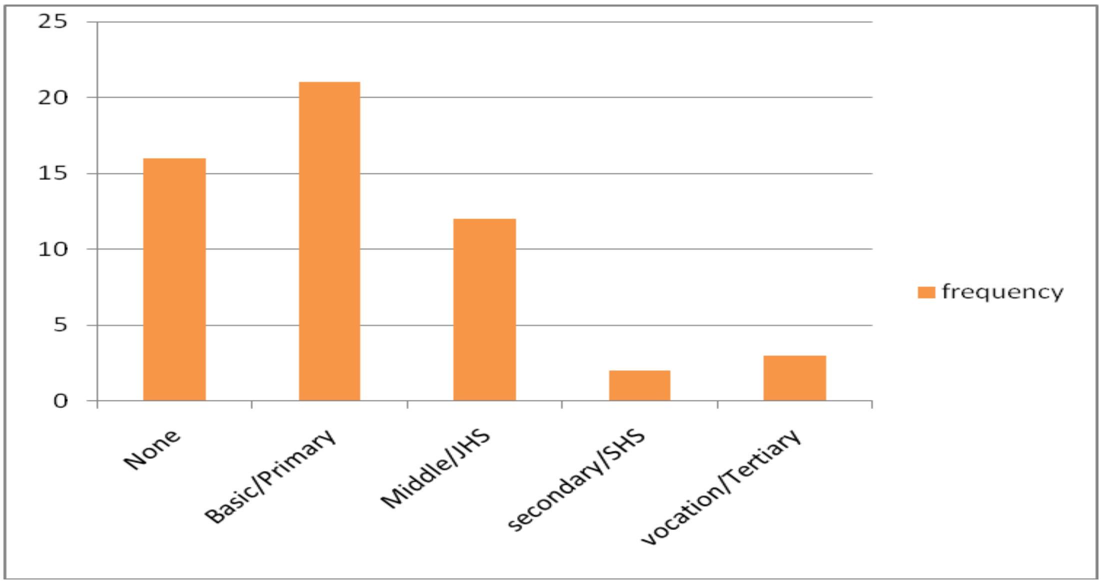

Figure 4.3: Households Heads Education Level

Source: Field survey, 2017

Majority of miners in the study area were people who were not married representing the highest percentage of the target population of miners. It therefore had a representation of 59.2% with a frequency of 58 whiles 37.8% and 3% (37 and 3) represented married and divorce respectively. Though marital status of respondents did not relatively influence mining activities each of the category could seek support from other family members when the need be. Some individuals who were married had their children supporting them especially in the area of transporting load, grinding and washing among others. Some other individuals could only rely on family members or groups that are formed at the site (see Figure 4.4).

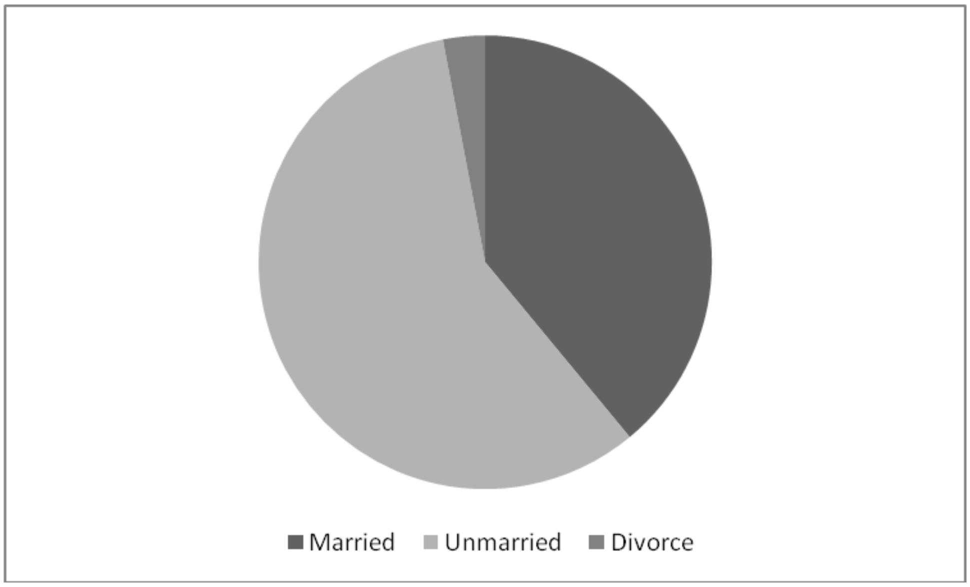

Figure 4.4: Marital Status of Miners (Respondents)

Source: Field survey, 2017

Apart from miners which are the target population, household's heads were also interviewed to gather information on strategies that are being employed to cope with the activities in the community. From Figure 4.5, respondents were married, unmarried, divorce or widow/widower. This marital status of household's heads did not influence their responses base on their knowledge of understanding of the activity

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as well as their ability to cope and develop strategies to manage with the negative impacts. Married household heads had the highest frequency of 43 representing 79.6%, unmarried got a frequency of 4 with 7.4% representation whiles divorce and widow/widower had frequencies 1 and 6 representing 1.9% and 11.1% respectively (Figure 4.5). Widow/widowers lamented on their inability to get support elsewhere and just need to take decisions on their own which sometimes makes life difficult living.

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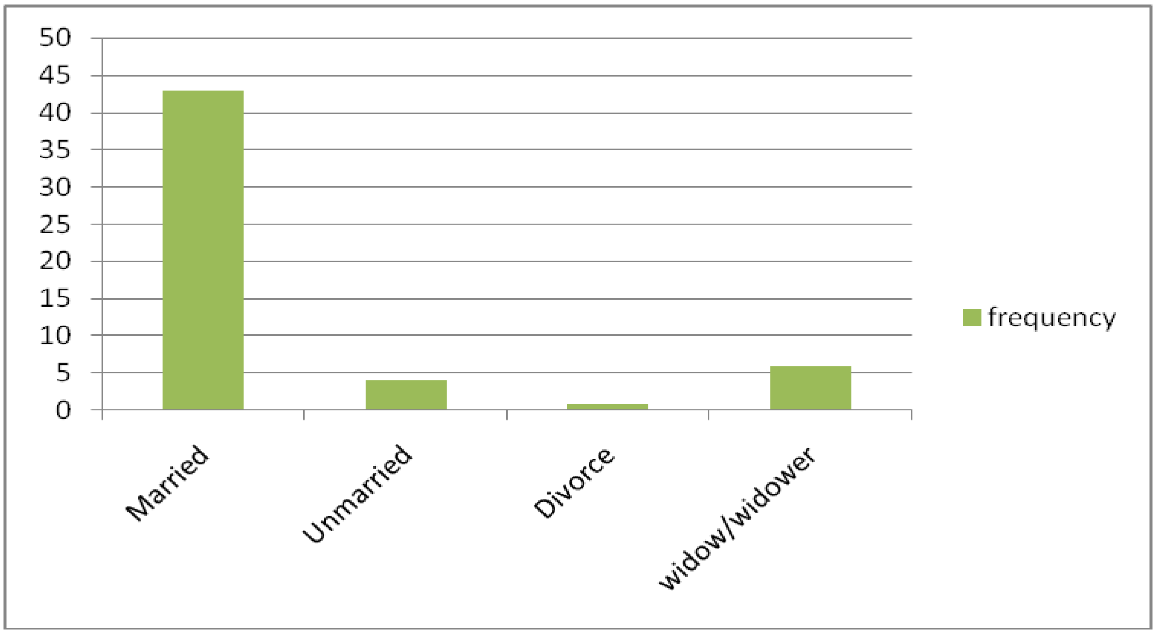

Figure 4.5: Marital Status of Household Heads

Source: Field survey, 2017

The results from the study also indicates that, respondents were not gainfully employed, especially in the public sector. Some respondents were solely engaged in artisanal mining while others were doing some other form of occupations alongside with artisanal gold mining. However, People with different occupational backgrounds have different levels of understanding and appreciation of issues especially issues regarding the health and environmental implications of mining. They also have

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different attitudes and insights concerning the nature of mining activities therefore, as shown in Figure 4.6, a frequency of 29 representing 29.6% were solely engaged in artisanal gold mining, the rest of the occupations identified though were also miners, they do it as a part-time job whiles the solely artisanal miners practice it all year round. Respondents that were also engaged in either or both mining included; hairdressing which had a frequency of 3 representing 3.1%, dressmaking/tailoring had a frequency of 2 representing 2%, Mechanics also got a frequency of 4 with 4.1%. Respondents that were engaged in trading stated that they are engaged in selling provisions, mobile phone credit cards, drinking bar among others. This therefore had a frequency of 11 representing 11.2% while Frequencies of 46 & 3 representing 46.9% & 3.1% were farming and Masson's respectively.

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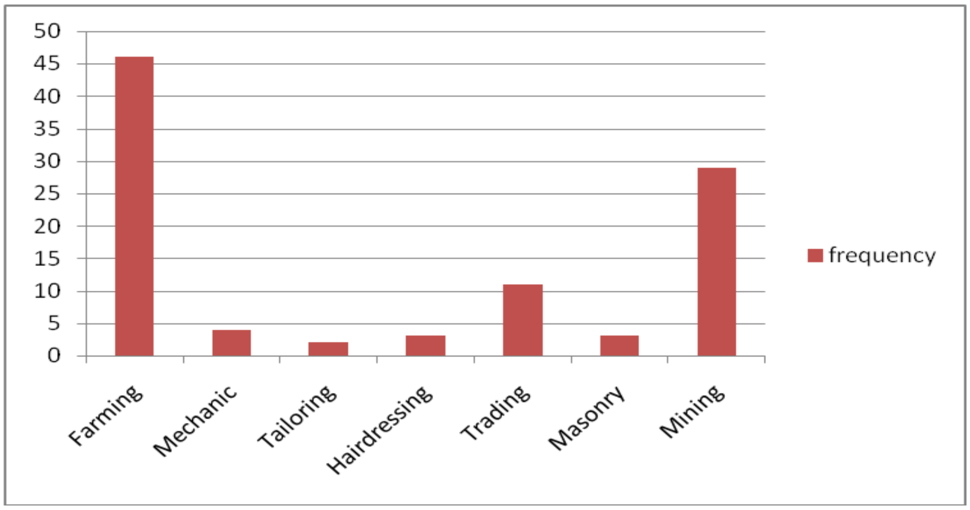

Figure 4.6: Occupational Distributions of Miners

Source: Field survey, 2017

Moreover, heads of households interviewed also indicated their various occupations some of them had to engage in some other ventures as a means of sustaining families because of the negative impacts they encounter daily because of the mining activity. Some were gainfully employed by government institutions such as schools and health centers among others. Those other individuals that were public service workers were engaged in bee keeping, smock weaving, farming, trading, hunting, fishing, while others are housewives and students etc. Table 4.6 gives details of the representations and percentages.

Table 4.6: Occupation of Household Heads

Occupation	Frequency	Percentage (%)
Civilian	8	14.8
Student	14	26.0
Housewife	6	11.1
Smock weaving	2	3.7
Hunting& fishing	5	9.3
Bee keeping	4	7.4
Farming	15	27.7
Total	54	100

Source: Field survey, 2017

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From Table 4.7, majority of the respondents were Christians with a frequency of 78 representing 50%, the second highest from the analyses are African Tradition (AFT) with a frequency of 49 presenting 31.4% with the lowest religion being Islam with 29 as frequency and 18.6%.

Table 4.7: Religion of Respondents

RELIGION	FREQUENCY	PERCENTAGE
ISLAMIC	29	18.6
CHRISTIANITY	78	50.0
TRADITION	49	31.4
TOTAL	156	100.0

Source: Field survey, 2017

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4.3 Nature of ASGM Practice in Kadema

From the study, it was realized that underground mining is a male dominated activity. It involves deep dig of dry land with gold deposits. Pits are dug so deep until they hit ore and it is basically done by male adults because it required a lot of physical energy which women cannot. Some of the activities which women and children assist in with regards to underground mining includes; digging, chiseling, gathering of blasted rocks into sacks, hoeing, and carrying load to the top ground for processing. They also transport stones and sand in basins, donkey carts to crushing and washing sites. This is often undertaken in the dry season because during raining season miners are prone to accidents and they are sometimes covered with running water underground.

The study revealed that miners are engaged in underground and surface mining (see Plate 4.1). Surface mining had a frequency of 41 representing 42% whiles underground mining had a frequency of 57 representing 58% (Figure 4.7). Surface mining on the other hand is mostly engaged in by women while underground mining is basically for men. For Surface mining, it involves digging dry or wetlands that have deposits of gold with pick axes and hoes. It was therefore detected that a machine is used to detect gold. Mining also involves dry and wet land excavation. About 2 to 5 meters feet is dug for the gold ore in the surface mining. It is basically seasonal, and depends to a large extent whether it is raining or dry season. Though not all miners mine all year round some do it either in the dry or wet seasons. It was realized that women and children especially prefer the raining season because water is easily available for gold ore processing as well as digging because the ground becomes soft.

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Plate 4.1: Mining sties at Kadema(Underground pit and Surface Mining)

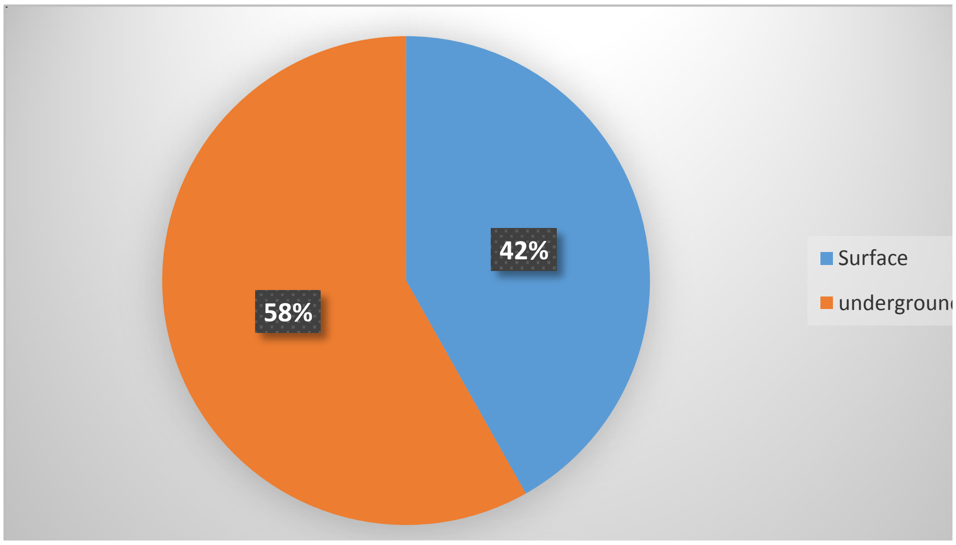

Figure 4.7: Methods of mining

Source: Field survey, 2017

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Miners were asked if they mined all year round and responses were either Yes or No. those who said ‘Yes’ had a frequency of 50(51%) and those who said ‘No’ had a frequency of 48(49%). Those who said ‘NO’ were further asked to state their preferred time of mining and the reason for those periods. Between January -March had a frequency of 40 representing 41%, April-June had a frequency of 30 representing 31%, July-September had the lowest frequency of 7 representing 7% the reason being because it is in the wet (raining period) whiles October-December had 21 representing 21%. Though some individuals who do not engage in any other activity mined all year round, others do it during some time of the year especially during the dry seasons because they are under other ventures in the wet seasons like agricultural farming. Majority of the miners prefer to undertake the activity in January to march because those periods are safe. Quite apart, it was also established that, there was no working time for miners irrespective of the age. You retire when you are tied. Responsibilities vary from individuals as some engage in digging or excavation, carrying of load, drying, grinding/pounding among others. Majority of them worked for themselves, others for employees to other operators and some worked for their own parents/relatives. To be able to raise enough money most of them were motivated to work whole day. As a result of the nature and duration of activity some indicated that they get too tired to do any work after mining while majority indicated that they are engaged in other jobs

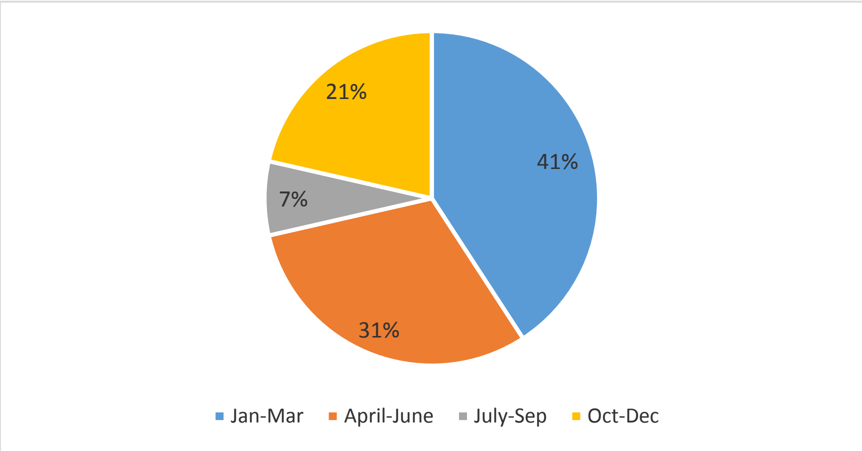

Figure 4.8: Preferred Mining Period
Source: Field survey, 2017.

From the analysis, equipment's that miners use during the mining process to the finishing point included, hammer, shovel, chisel, donkey-cart, blanket, bucket, sieve, bowl, washing board, pick-axe, hoe, head pan, cutlass, touch light, motor and pistil, grinding mill ('chanfine") and a rope. Not all the miners use these equipment's, especially women, since they do not involve in underground mining. During the raining season sand is collected from various points or mined pits and sent for drying

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before grinding. The grinding process involves two stages; thus the sand is grounded rough before transferring to the smoother machine. Miners source of water is either dam or rain water. Sometimes miners stand by road sides to wash their sand in the runing water and water that has been collected in the dug pits during rainfalls. However, the mining process in Kadema is as follows (see Plate 4.2 a – f):

- Surveying the land with machines to identify gold debris; which is usually ‘try an error ‘for of testing for gold samples
- Soil sample is tested and if it proves then mining starts;
- Land preparation/clearing;
- Digging underground to a depth of about 100m and sometimes blasting underground hard rock’s; and in surface mining which is mostly done by women and children, soils are collected dried especially during the rainy season before grinding for processing
- Stones and sand is collected and grinded/pounded; even though, most miners prefer using the grinding mail, fewer rely on pounding because it is less expensive and sometimes does not involve the use of money.
- Washing equipment’s are set-up and water gotten from the dam to start the process;
- The mixture of the powered red soil and water is sieved to remove gold;
- Amalgamation process with chemical (mercury);
- Heat is applied;
- Scaling and the sales;

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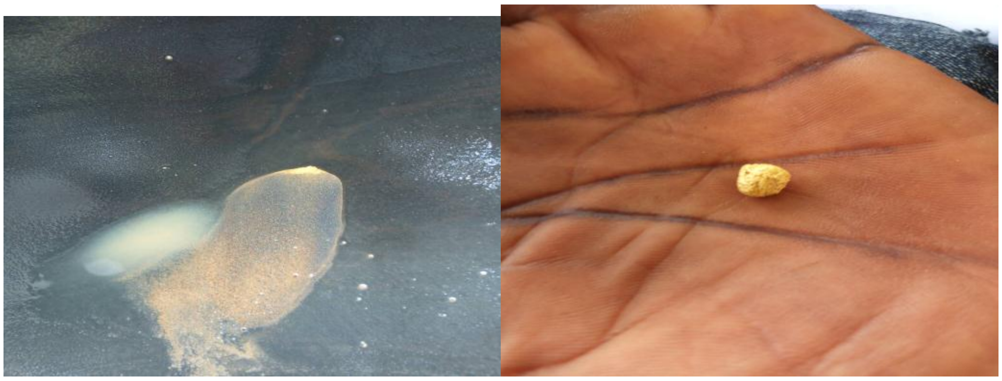
Plate 4.2 a and b: Testing to soil sample and stone ore

Plates 4.2 c and d: Washing of powdered ore to remove gold



Plates 4.2 e and f: Final process of gold separation

It is also interesting to note that women's activities in the mining process are very different from that of the men in the community. For the women, they gather soils around the underground pits straight to go and wash which they call '*dig and wash*'. It does not involve digging but does involve grinding some stones if the need be. The

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nature of mining in the community is not for a corporate entity but rather individuals or groups.

It was also realized that miners belong to groups/associations ranging from 3 – 20+ (see Figure 4.9).

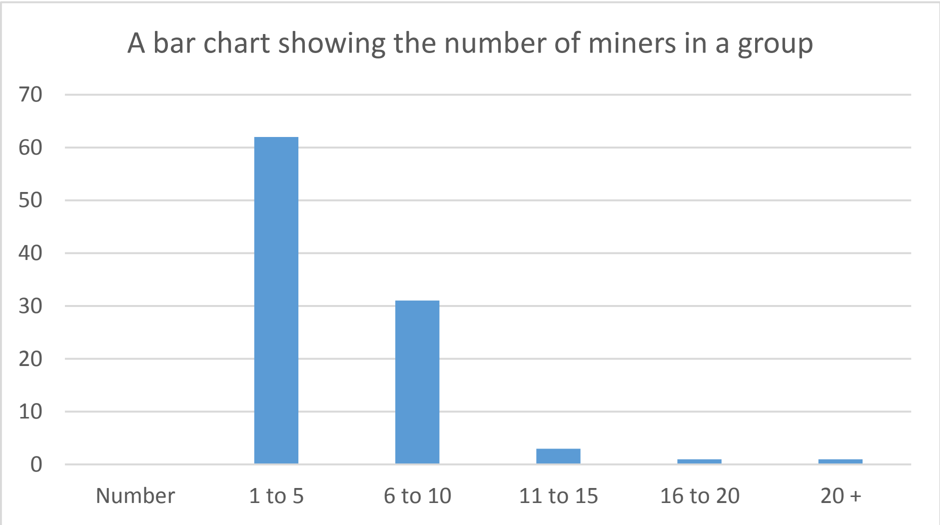

Figure 4.9: Number of miners in a group

Source: Field survey, 2017

From the Figure above, miners' group/association ranges from, 1-5 had a frequency of 62 representing 63.3%, 6-10 had a frequency of 31 representing 31.6 and 11-15 also got a frequency of 3 representing 3.1 whiles 16-20 and 20 + had equal frequency and percentage which each had 1 and 1%. It was also revealed in the analysis that miners are not aware of Precious Minerals Marketing Corporation and therefore make sales of the gold at the mining sites to individual gold dealers and sometimes make sales at the regional or district capital. It was also realized that, some miners have their relatives helping them (sisters, brothers, sons, daughters etc.).

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From Figure 4.10, respondents who had been in the activity for less than a year had a frequency of 18 representing18.4%, 1-3 years had 31.6%, 4-6years 20 (20.4%), 7-10 years 26 (26.5%) and 10 years above had a frequency of 3 (3.1%).

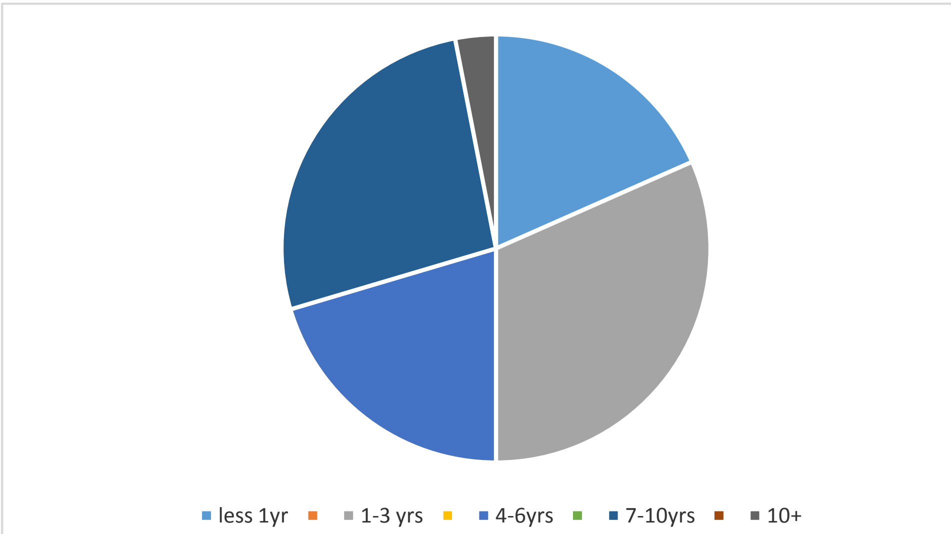

Figure 4.10: Duration of Miners in Mining Activity
Source: Field survey, 2017

4.4 Environmental Implications of ASGM in Kadema

A total of 54 household heads were interviewed on the environmental impacts of the mining activity. The following responses were gotten from the field to ascertain severity of the impacts. From Figure 4.11 it depicts responses, a frequency of 23 household heads revealed severity of the mining impact representing 43% thus being the highest. A frequency of 21 with 39% showed severe and 10 representing 18% stated not being severe. Plate 4.3 shows evidence of mining's impacts on the physical environment.

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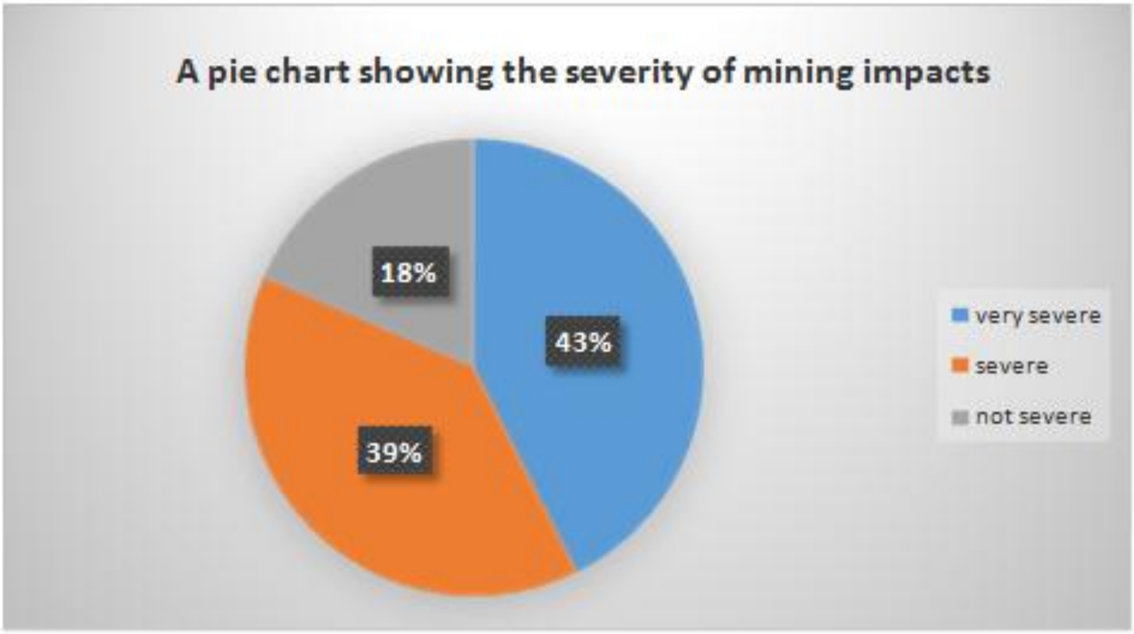

Figure 4.11: Household heads' views on the impact of mining on the environment

Source; Author's Construct, 2017

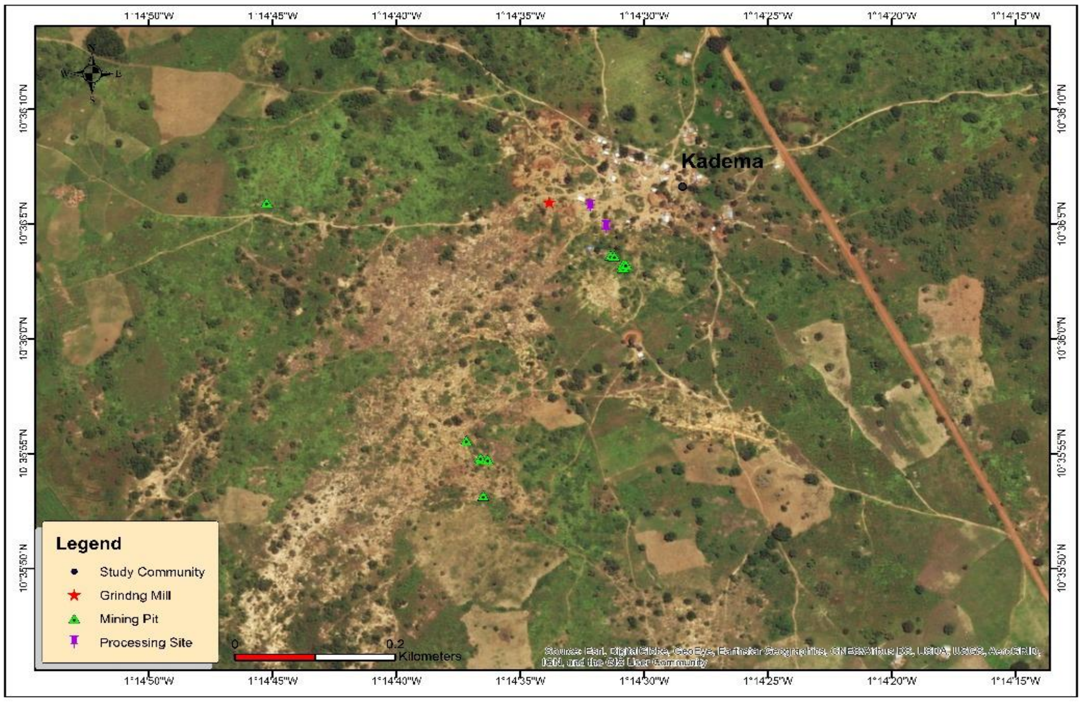

Figure 4.12: Mining's impacts on land and vegetation
Source: Author's Construct, 2017

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Plate 4.3: Mining's impacts on the physical environment

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From the responses, household heads were probed to state the impacts of the mining activity on the environment since majority of the responses showed the impacts of the activity is very severe (see Figure 4.5).

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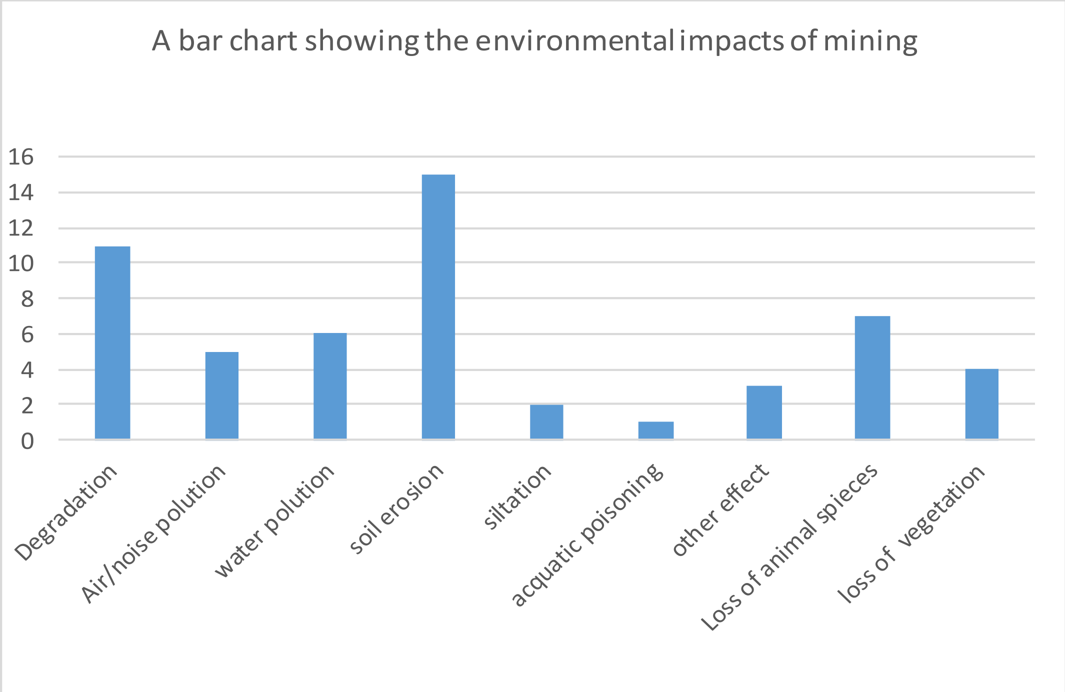

Figure 4.13: Environmental impacts of mining

Source: Field survey, 2017

From the Figure 4.13, analyses showed that soil erosion has the highest frequency of 15(27.8%) followed by land degradation with 11(20.4%), and animal loss (as a result of animals falling in the underground pits) with 7(13%). With the grinding of rocks and digging, it produces a lot of noise and dust which affects the environment with 5(9.3%), water pollution had 6(11.1%), responses revealed that loss of vegetation took a frequency of 4(7.4%) and this is as a result of clearing the land to embark on mining. Siltation and aquatic poisoning took 2(3.7%) and 1(1.9%) respectively, according to Akabzaa and Darimani (2001), in a study at Tarkwa, mining has degenerated into destruction of the luxuriant plant life, biodiversity, cultural sites and water bodies. Agricultural farm lands are largely destroyed through mining thereby reducing the availability of farm land, reducing agricultural activities and consequently increasing shortages of food and other agricultural produce. Also, according to Laari et al. (2015), in a study in the Upper West Region, mining has impacted the environment as it resulted in land degradation and environmental burden from these minerals extraction continues to impact negatively in these mining areas. Large tracts of forest cover or vegetation was lost in South America as a result of similar gold mining (Durán et al., 2013; Asner et al., 2013). In Ghana, studies have shown loss of vegetation around gold mining areas (Agyeman, 2007; Schueler, 2011).

The Reponses from the study also revealed the various different size of land that is being cleared by miners in a year thus ranging from 1-5 acres. From the 54 household heads, a frequency of 16(29.6%) indicated that one acre is being cleared yearly by miners, a frequency of 18(33.3%) also stated that 2 acres of land is been used representing highest, 3 acres cleared by miners yearly also had a frequency 10(18.5%), 4 and 5 acres had frequencies of 4(7.4%) and 3(5.6%) respectively. Figure 4.14 gives further details.

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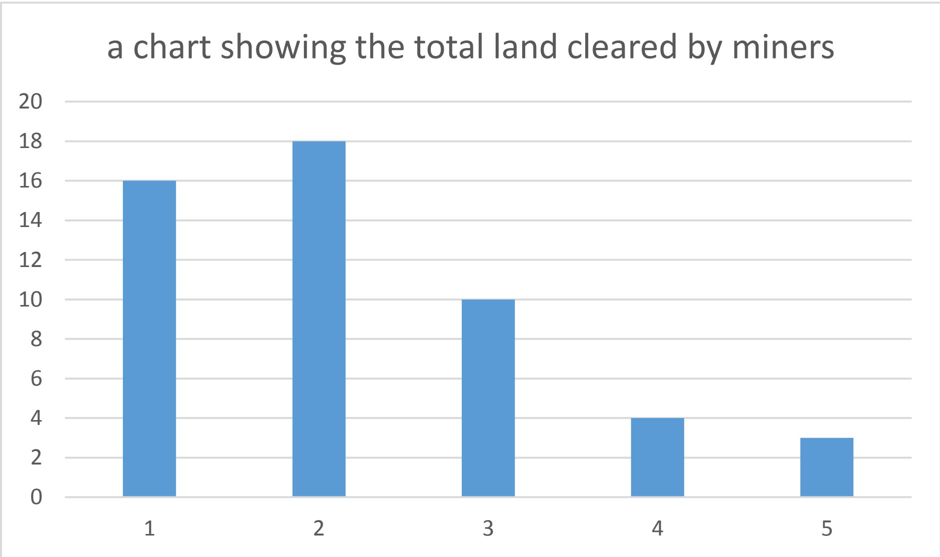

Figure 4.14: Total land area cleared by miners in a year (acres)

Source: Field survey, 2017

In Tables 4.7 below, also reveals how mining activities have affected farm lands availability because a large portion of land is destroyed and will need extra efforts and resources to reclaim. A frequency of 38 representing 70.4% responded "YES" to the fact that the activity has indeed reduced land availability and a frequency of 16 representing 29.6% responded "NO".

Table 4.7: Farm land availability

	Frequency	**Percent**
YES	38	70.4
NO	16	29.6
Total	54	100.

Source: Field survey, 2017

In the analysis as shown in the Figure 4.15, ground and surface water has been contaminated. With respondents saying "Yes" representing 63.0% with a frequency of 34 and "NO" representing 37.0% with a frequency of 20.

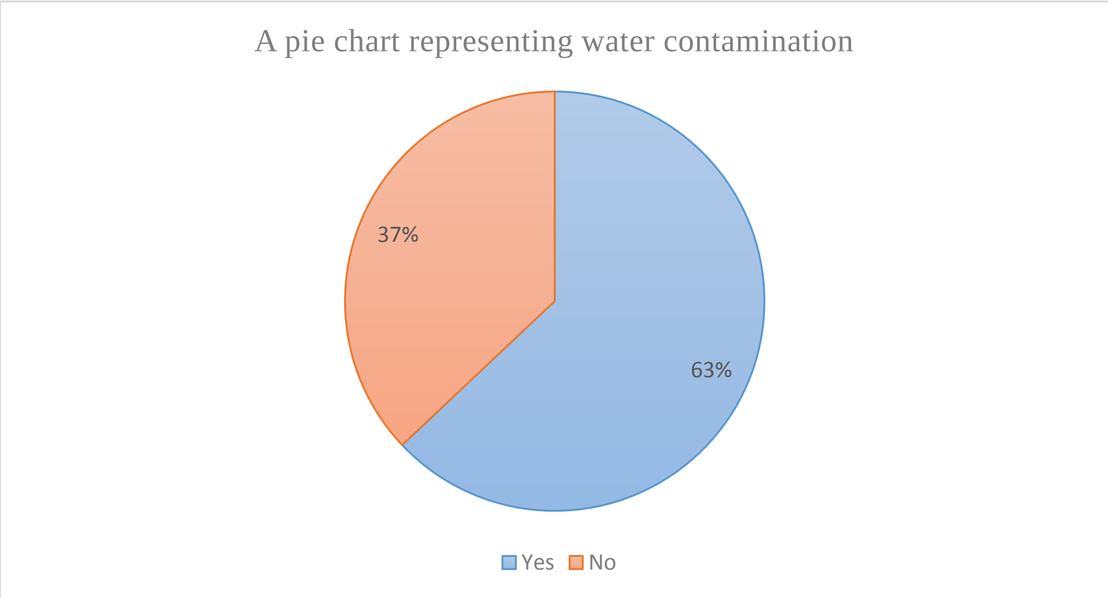

Figure 4.15: Household heads' views on ground and surface water contamination

Source: Field survey, 2017

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In other to validate responses on whether water sources are contaminated, a sample of water was drawn from a dam which a major source of water for the study community to a water laboratory for water quality testing. The laboratory results revealed that the water source in the community for households' consumption is indeed not portable except conductivity. This therefore goes to confirm the responses from the analyses. Table 4.10 presents the laboratory result

Table 4.10: Water Quality Test Results

Parameter	Method No.	Unit	Value	WHO Guideline
Conductivity	1	µs/cm	241.3	……
Color(Apparent)	2	Hz	47	15
Turbidity	3	NTU	570	5.0
pH	4	pH unit	9.14	6.5-8.5
The test was conducted in Tamale at the Department of Water Quality Laboratory. value recommended guidelines for drinking water except that of conductivity The above parameters analyzed are not within the WHO's and Ghana Standards Authority's				

Source: Authors Field Research Work, 2017

From Table 4.11, land reclamation was an activity miners don't undertake after mining though responses showed it was done but it was evident that such was not being practiced at the site. The researcher observed that hips were pilled whiles both underground and surface pits where left uncovered which eventually became breeding grounds for mosquitoes thereby endangering both humans and animals. Those miners who responded 'Yes' to land reclamation had a frequency of 6 representing 6.1% and 92 responded 'No' with 93.9% being the highest. Various reasons were given why it was not done.

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Table 4.11: Land Reclamation

	Frequency	Percent
YES	6	6.1
NO	92	93.9
Total	98	100.0

Source: Field survey, 2017

Miners indicated that land is not reclaimed because they want to revisit the dug pits after a period of time and this is shown in Figure 4.7 with a frequency of 30(30.6%). Others also said they are not responsible for the dug pits and therefore will not make efforts to reclaim damages caused by another person with a frequency of 19(19.4%). Also, one reason why land is not reclaimed at the site is that rains will wash soils back into the pits - 13(13.3%). However, some respondents indicated that reclaiming land was not a necessary thing and for the purposes of reusing soils - 16(16.3%) and 20(20.4%) respectively. Lands that are not reclaimed have become grounds for water sources and majority of miners rely on their sources for the mining operations during the raining seasons. Plate 4.4 shows examples of non-reclaimed lands.

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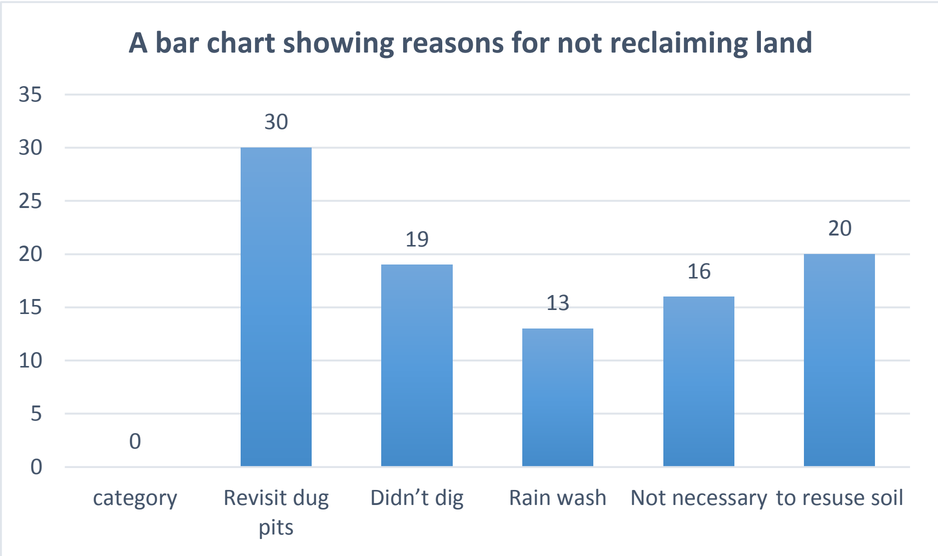

Figure 4.16: Reason for not reclaiming land

Source: Field survey, 2017

The researcher was also interested in knowing whether permits are being obtained by miners before embarking on mining activities. From Figure 4.17, some respondents obtained permits from the traditional authority, family heads, no authorized permit obtained and others who did not reveal where permit was obtained. The highest institution where permit was obtained is the traditional authority with a frequency of 53(54.1%), permit obtained from family heads and no permit obtained had a representation of 20(20.4%) and 15(15.3%) respectively. Others did not reveal the institution where permit was obtained and thus had a representation of 10(10.2%) being the lowest.

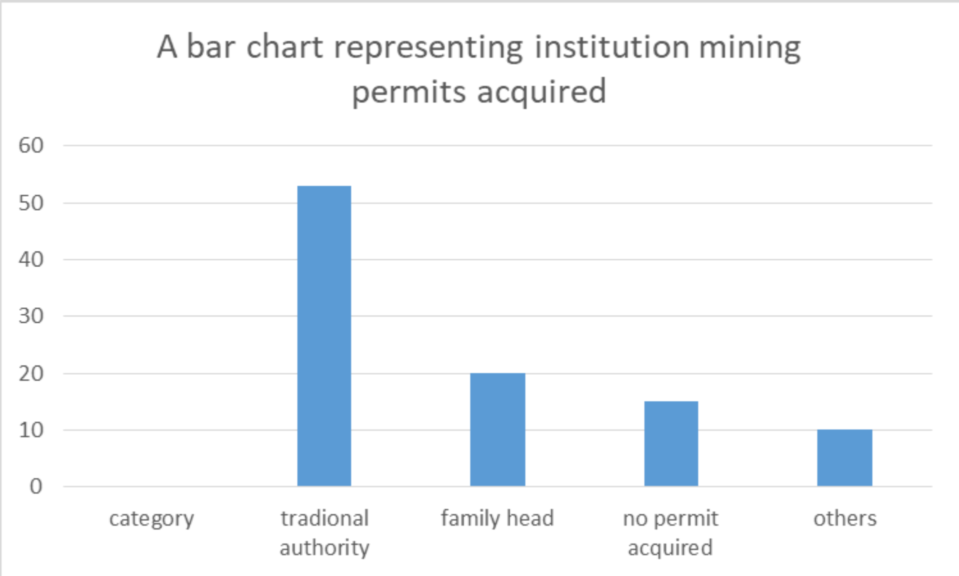

Figure 4.17: Institutions where permits are obtained

Source: Field survey, 2017

Also, Figure 4.18 shows the forms of payments made to the various institutions by the 98 miners at the site. Respondents who made cash payments paid amounts ranging from GHS 50-300 which had a frequency of 23 representing 23%, some respondents also said they only make contributions in kind or cash during festive seasons like

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festivals (Feok), funerals, etc. which had a frequency of 40 representing 40%. Some miners have also been giving the mine stones to these authorities to also process with a frequency of 29 representing 29% and the lowest frequency of 6 representing 6% being miners who did not pay anything before undertaking any activity at the site.

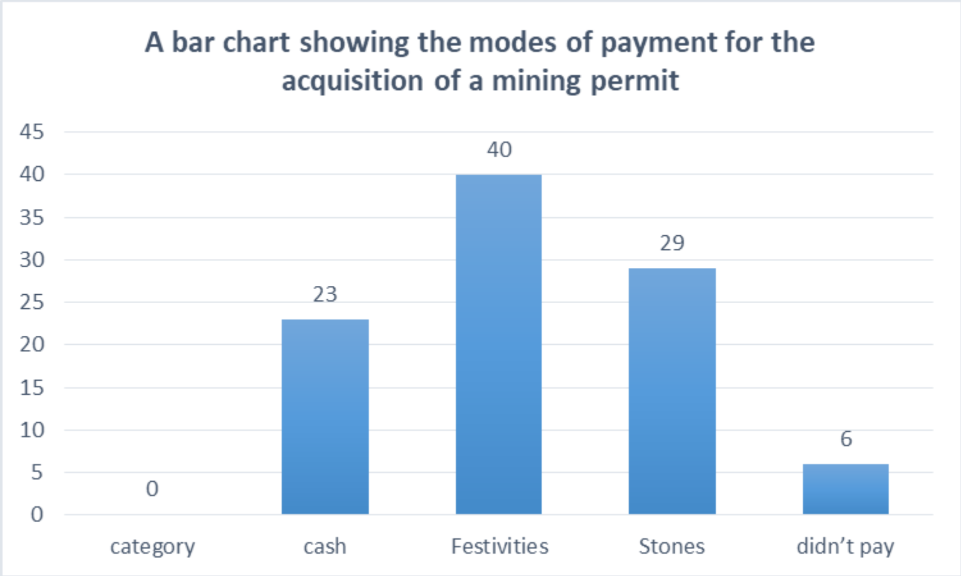

Figure 4.18: Mode of land acquisition payments

Source: Field survey, 2017

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Out of the total 98 miners interviewed, 30(30.6%) responded 'NO' to land acquisition, meaning they did not acquire land before engaging in the activity at the site in Kadema, 68 representing 69.4% responded "YES" indicating that they have acquired some form of land before embarking on the activity in the community and various forms of payments were made in that regard (See Table 4.12). Figure 4.19 is a chart showing the amounts paid for land acquisition.

Table 4.12: Land Acquisition

	Frequency	Percent
No	30	30.6
Yes	68	69.4
Total	98	100

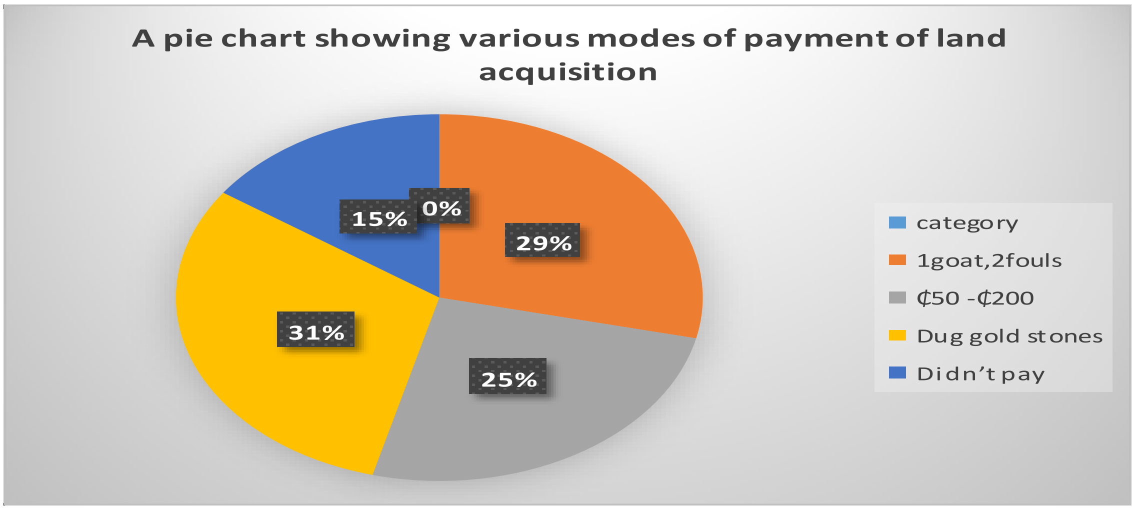

Figure 4.19: Amounts paid for land acquisition

Source: Field survey, 2017.

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Form the above figure, a frequency of 28(29%) gave 1 Goat, 2 Fouls to the necessary authority which is the second highest, 25(25%) made cash payment ranging from GHS50-200 whiles 15(15%) and 30(31%) gave some dug gold stones and some others didn't pay anything respectively. The respondents who didn't pay indicated that they were from families that have control over the sites and that they are indigenes and for that reason had no reason to acquire any land that involves payment from any institution.

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4.5 Health Implications of Mining in Kadema

According to Tschakert and Singha (2007), in a clinical study, increasing exposure to mercury could cause health challenges such as kidney pain, respiratory problems, neurological damage, dizziness, gingivitis, muscular tremors and psycho-pathological symptoms including depression and exaggerated emotional responses, which can be mistaken for alcoholism, fever, or malaria, dysfunction of kidneys, memory loss, miscarriages, vomiting, and potentially death. From Figure 4.20, the study got frequencies and percentages that have been illustrated showing numerous health ailments. Malaria being the highest with a frequency 21(21.4%). It was realized from the health center that previous records of malaria was low but since the inception of mining activities, the area has always recorded the highest figure of malaria in the district, typhoid had a representation of 15(15.3%), respondents who encountered cardiovascular problems 5(5.1%), catarrh has a 12(12.4%) representation, waist pain 7(7.1%), reptiles attack had 10(10.2%). Due to poor sanitation conditions such as uncovered mining pits, stock piled sand, unburned rubbish etc the area has become prone to reptiles such as snakes, scorpions especially and have constantly attacked miners during operations. Diarrhea also had 5(5.1%) and cholera with the lowest frequency of 1(1.0%) and asthma 3(3.1%). Respondents said that the dust from the operations has affected them though they were not asthmatic patients. Dislocations had a representation of 9(9.1%) and finally chest pains represent 10(10.2%) due to the vigorous nature of the work.

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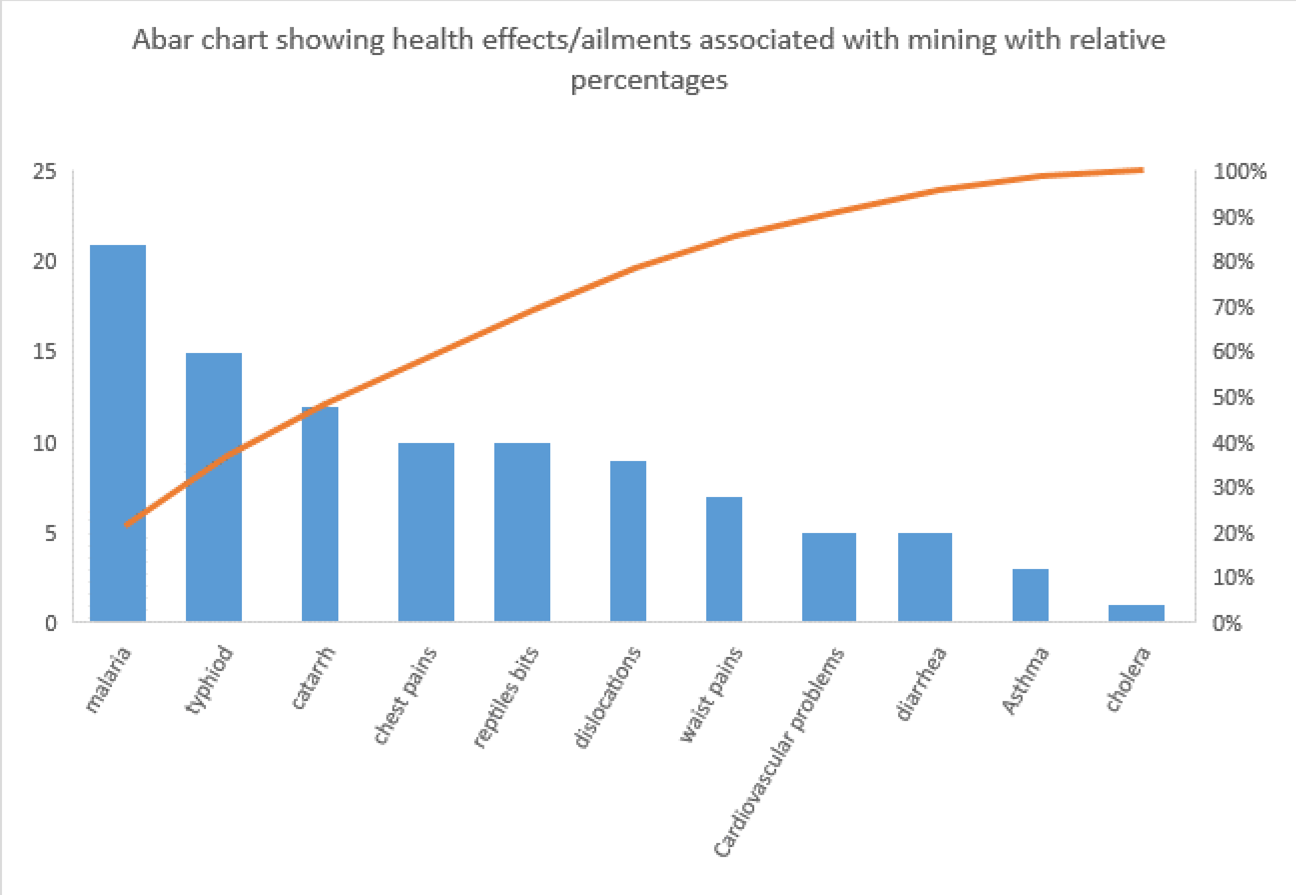

Figure 4.20: Health Effects/Ailments of Mining

Source: Field survey, 2017

From Table 4.14, respondents were asked if they had obtained any form of injury ever since they started the mining operations. Some responded "YES" and others "NO". Those who responded yes had a frequency of 48 representing 49% and the no's 50 representing 51%. Those who answered yes where further asked to state the type of injury obtained. It was therefore gotten that dislocations either of a hand or leg, it therefore got a percentage of 13.3% representing a frequency of 13. It was also reported that reptiles such as snakes and scorpions have constantly attacked some individuals during the processes; which also got a frequency of 21 representing 21.4%.

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Table 4.13: Physical Injuries Obtained by Miners in the Process

	Frequency	Percent
No	50	51
Yes	48	49
Total	98	100

Source: Field survey, 2017

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Some underground miners who usually blast the rocks in the underground pit in other to obtained gold also reported that they mistakenly set the blaster on while in the pit and nearly lost their lives. This injury got a frequency of 34 and 34.7% representing the highest injury obtained and finally others who mistakenly bomb into the underground pits also got their legs/hand broken and some other minor injuries as well as some others who also got deep cuts from chisel, hammer, pistil, hoe, etc. representing 10(10.2%) and 30(30.6%) respectively. Figure 4.21 below further gives a pictorial illustration of the injuries obtained. The most frequently occurring causes of accidents which related to mining is handling of tools and handling heavy loads, collapse of pits at the mines is the most prevalent causes of injuries at the site. However, reptiles such as scorpions and snakes are constantly attacking miners and households individuals as they process their gold soils samples. There are therefore similarities in the injury types between the study community, Ghana and other parts of the world like the Democratic Republic of Congo even though the principal causes of accidents resulting in injuries have been variously described. Jennings cites the five most frequent causes as falling of rocks, lack of ventilation, misuse of explosives, lack of technical training and training on regulatory compliance and obsolete and poorly maintained equipment. However, there have been numerous reports of fatalities and brutal injuries among artisanal and small-scale gold miners. Classification on the cause of accidents were obtained from the health worker though the history gotten from the patients during the clinical encounter, and were indicated as part of the finding, which was captured in the records of the facility. There were no records on the cause of ailments for majority of the cases. Cases on which records existed included collapse of the mine pit which is indicated as the most frequent cause of accidents resulting in physical injuries, explosive blast injuries, and falls at the mining site, several miners fell into pits, and others fell at site after being injured by a falling very heavy metallic mining object. Even though there was no clear cause for other injuries by the health worker records he testified that there has been other health care's that are not captured by the facility because some individuals do not use the facility while others also rely on traditional medicine.

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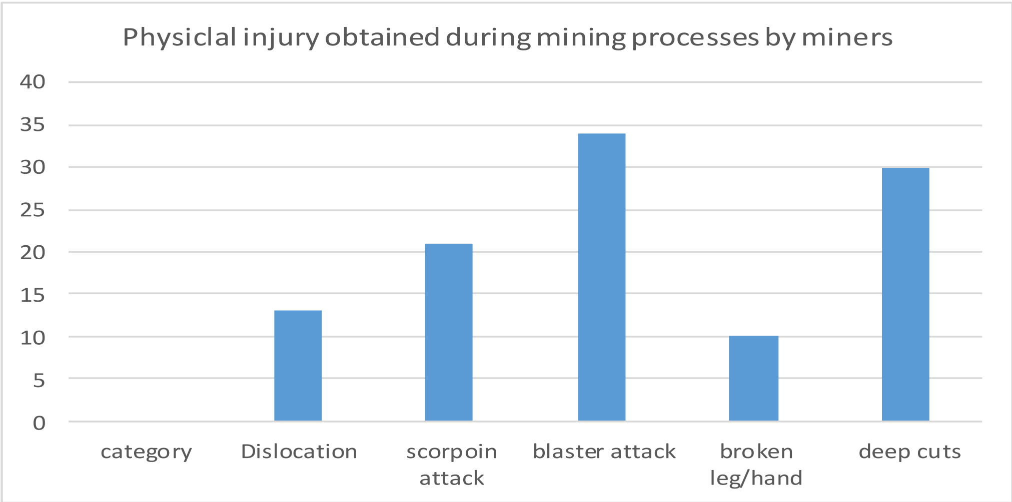

Figure 4.21: Physical injuries obtained by miners

Source: Field survey, 2017.

From the analysis, 152 respondents comprising of artisanal miners and households heads were interviewed to know where they seek for health care in the community since the activity is coming with a lot of health issues. It was realized that a frequency of 55 comprising 37% visit health centers. Those who visit the drugs stores had a frequency of 40 representing 26%, herbal treatment (traditional treatment) got a frequency of 31 representing 20% whiles self-medication took a frequency of 26 representing 17%. Figure 4.22 below gives a pictorial representation of the responses.

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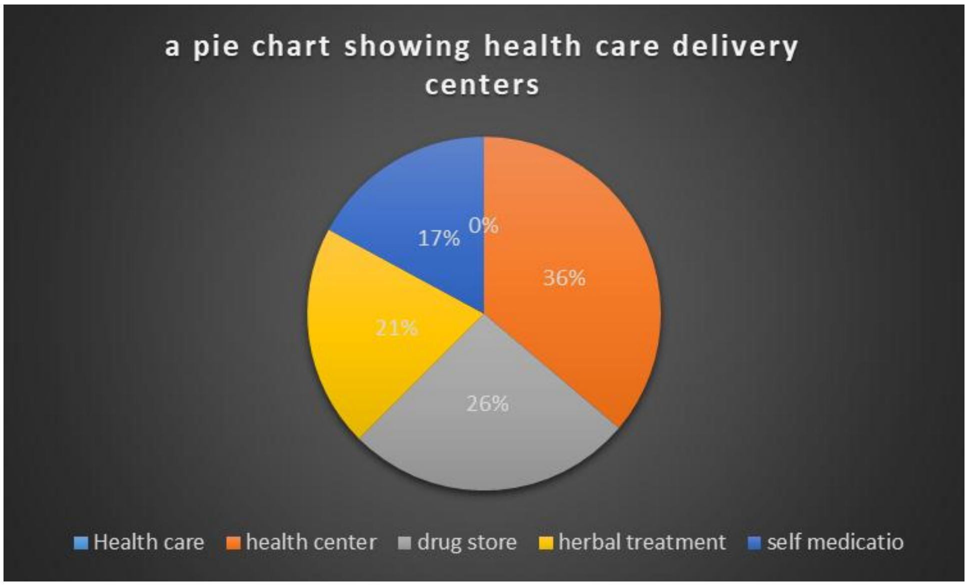

Figure 4.22: Health care delivery centers

Source: Field survey, 2017

It was also realized from the responses gotten from the District Assembly and the Health Center that, various measures have been put in place to support the communities in terms of health care delivery. The Assembly has constructed a CHPS compound for the community as well us provided staff and equipment to manage minor health issues. The health center responses were that, there has been free health screening and immunizations of early childhood killer diseases in the communities as a way of supporting them. Though some community members have registered under

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the National Health Insurance Scheme (NHIS), others are yet to register. The Assembly has also trained community health volunteers to give first aid sometimes in the absence of a health work. Health workers have constantly visited homes to teach and educate them on health issues as well as sanitation issues so as to stay healthy devoid of sickness.

Table 4.15 indicates that health campaigns have been on-going at the community to by various institutions and organizations. Some respondents have “YES) responses representing 57(58.2%) and “NO” had 41(41.8%). The yes responses gave various campaigns organized by the Ghana Health Service, District Assembly and some NGOs.

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Table 4.14: Respondents’ awareness of Health campaign programs to educate people on mining activities

	Frequency	**Percent**
Yes	57	58.2
No	41	41.8
Total	98	100

Source: Field survey, 2017.

From Figure 4.23 below, reproductive health talks had a representation of 21.4% with a frequency of 21, malaria control and prevention also had a frequency of 12(12.2%), disease control and prevention and family planning had 26(26.5%) and 17(17.3%) respectively. General Sensitization/education on mining activities and general wellbeing had 22(22.2%).

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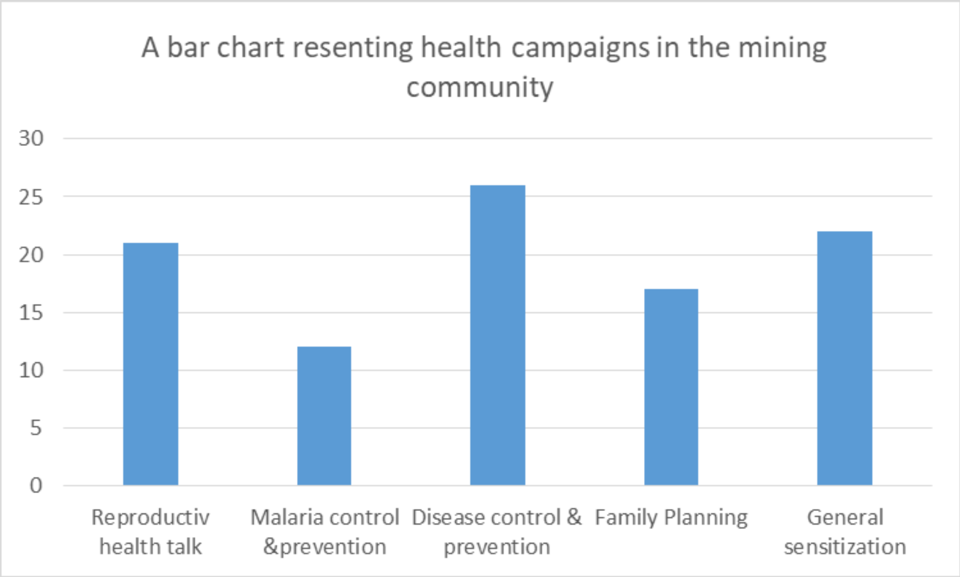

Figure 4.23: Respondents' knowledge of health campaign programs organized by government institutions

Source: Field survey, 2017.

4.6 Households' Coping Strategies against the Effects of ASGM

From the total 54 household heads, alternative livelihoods have been established as a result of the effects of mining activities in the community. This is because some farmers have lost their farm lands and need to engage in some other ventures for a living. It is therefore shown in Figure 4.24 below some livelihood alternatives by some HHs. From the figure, households have constantly engaged in non-forest timber products (NTFP) such as shea nut picking, dawadawa, baobao and tamarine representing a frequency of 14(26%) involving the majority of households. Others have also resorted to food vending at the mining site since a great number of people are constantly working at the site with a frequency of 5 (9%). For labor working group it had a frequency of 12(22. %). Mechanic work (motor and bicycle repair) and civil servant had equal representation with a frequency 3(6%) each. A frequency of 10(19%) represented people who are engaged in shea and dawadawa processing

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whiles 4(7%) and 2(4%) represented provisions shop and beer bar respectively and finally a frequency of 1 representing 2% engaged in animal rearing. Though, according to Ontoyin and Agyeman, (2014) in a study conducted in the Talensi-Nabdam, identified some coping strategies as land reclamation, resettlement of farmland, control of animal movements or tethering, resort to mining, resort to alternative livelihoods alongside agriculture.

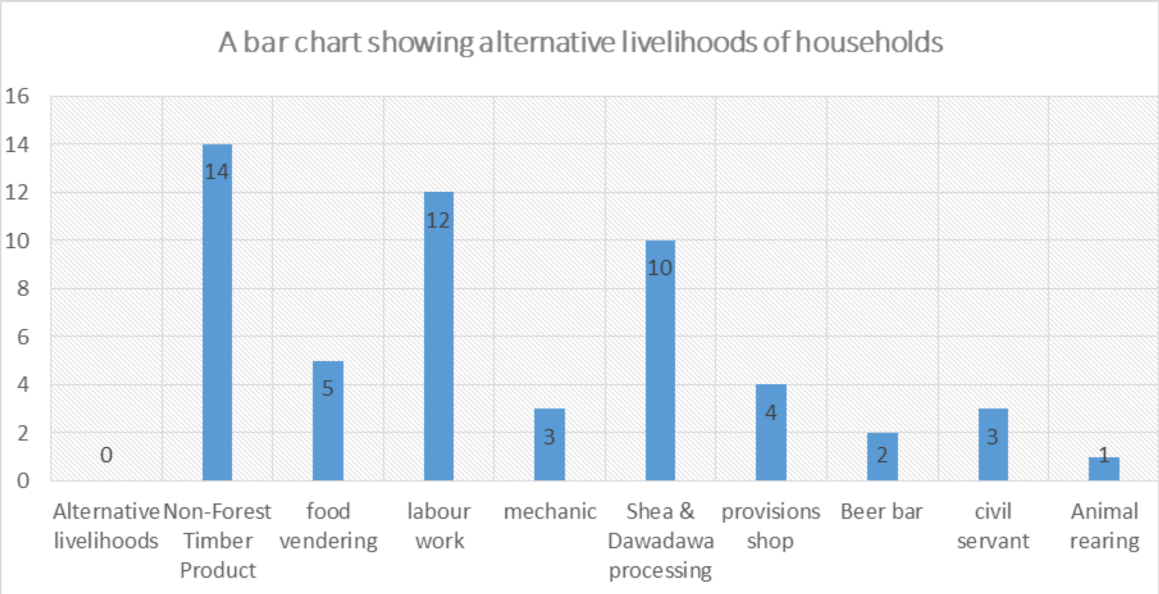

Figure 4.24: Households' alternative livelihoods

Source; Author's Construct, 2017

Agricultural lands have been largely affected rendering a lot of the land owners unable to farm on those parcels. However, from the 54 household heads interviewed, a frequency of 34 representing 63% which is the highest representation, others have resort fertilizer/compost application on the available pieces of farm land to them also with a frequency of 10 representing 19% while those with gardens and forest lands had a frequency of 1 (2%) and 9 (16%) respectively (Figure 4.25).

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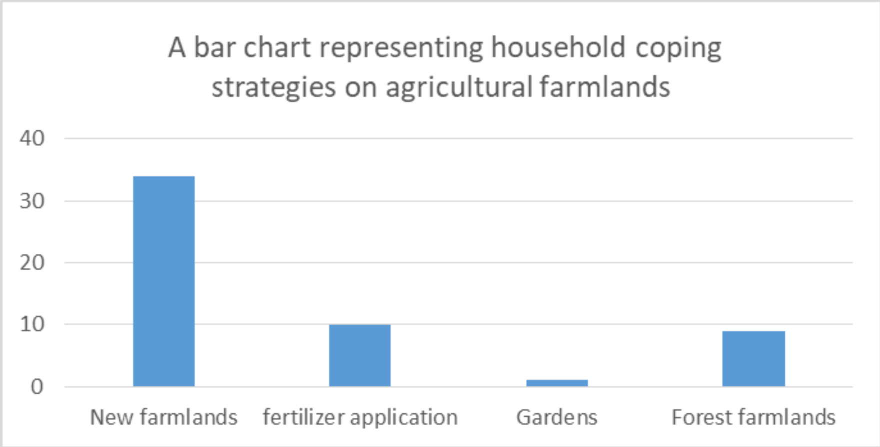

Figure 4.25: Households' coping strategies on agricultural lands

Source: Field survey, 2017.

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Apart from the alternative livelihoods that households are engaged in, they have developed some coping strategies to deal with the water situation in the community. Some households treat water before using it for any domestic work. They allow it to settle after some minutes before the sieve it with a clean cloth. This had a frequency representation of 3 with 6% (Figure 4.26). Others have also connected their households to the Ghana Water Company Limited's (GWCL's) water services representing a frequency of 5 and 9%. A frequency of 10 representing 19% constantly drops Naphthalene (canfer) as a way of purifying the water for daily use. It was evident from the analysis that majority of households buy water for domestic use representing a frequency of 26 and 48%, those who have 'wells' and have provided a covering/lid for the source had a frequency of 6 representing 11% whiles those who collect rain water for use, especially during the wet season, had 4 representing 7%.

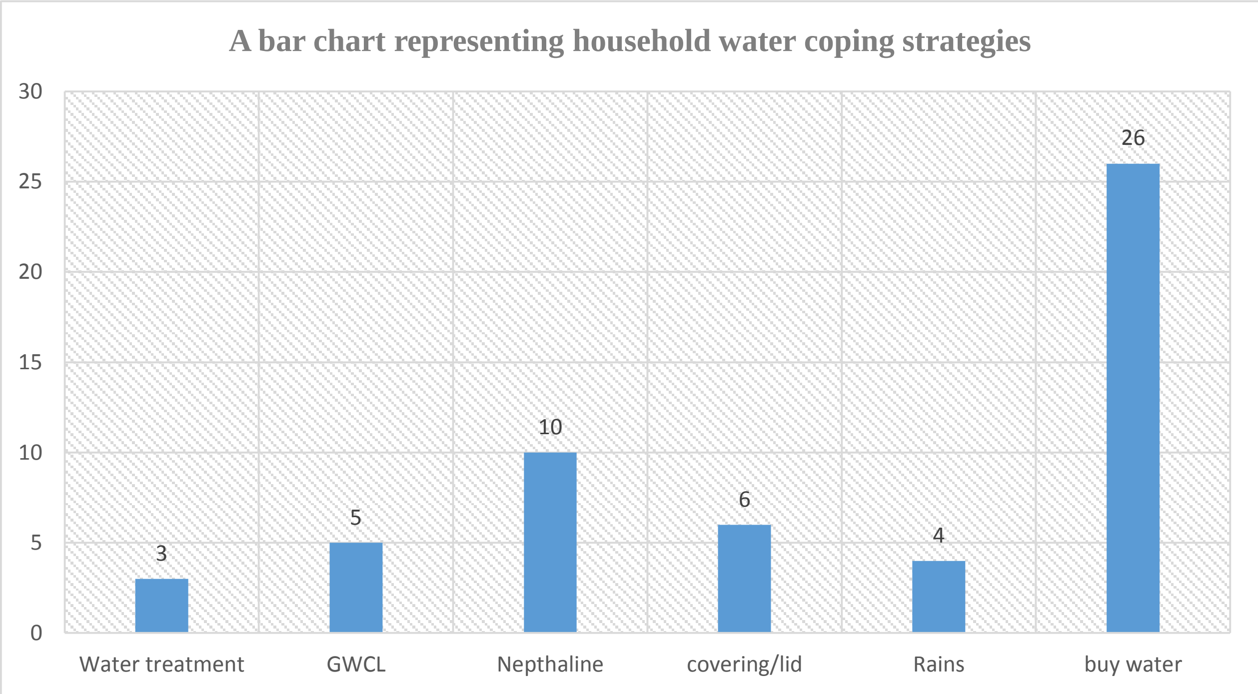

Figure 4.26: Households' coping strategies on the effects ASGM on water quality
Source: Field survey, 2017

Households were also interviewed on their source of water on livelihood activities. From the analysis it was noted that a frequency of 14 representing 26% rely on boreholes, 26 representing 48 uses 'well' being the majority, whiles 5(9%) and 9(17%) representing dam and other sources respectively. Figure 4.27 depicts the sources of household water for livelihoods

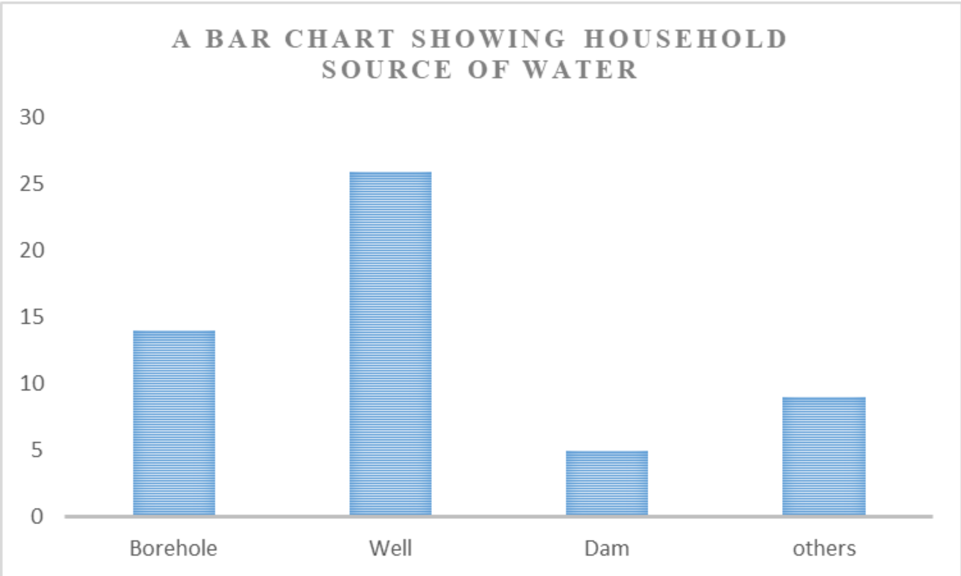

Figure 4.27: Households sources of water
Source: Field survey, 2017.

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With vegetation, the highest frequency 43 representing 80% of the households are doing nothing about the impact on vegetation, 5(9%) intend to plant economic trees around their homes while 2(4%) planted moringa trees at home (Figure 4.28). Out of the 54 households, some have kept efforts by sensitizing/educating miners not to destroy the vegetation especially trees representing a frequency of 4 and 7%.

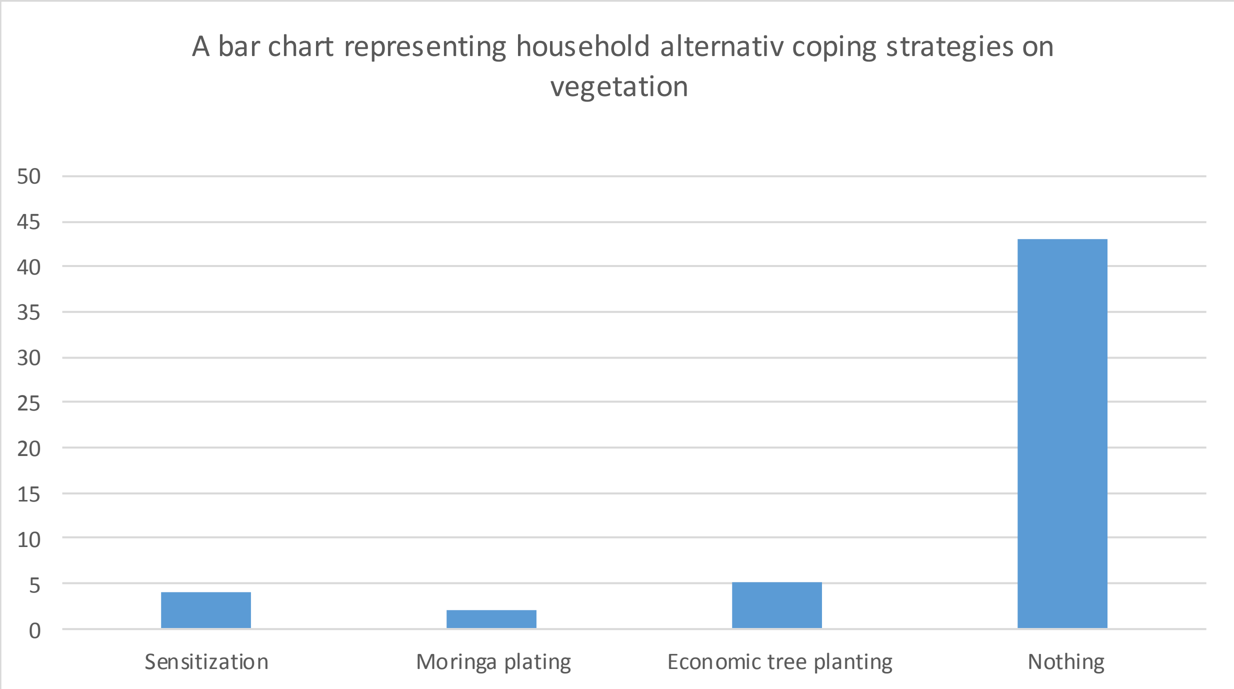

Figure 4.28: Households' coping Strategies on destruction of vegetation

Source: Field survey, 2017.

Even though households are trying so hard to cope with the activity in the community, they are still faced with a lot of challenges as stated in as shown in Figure 4.29. Accidents (affecting both animals and humans) have constantly been occurring due to the inability to see or identify underground mining pits and constant vibration, especially during blasting. This is often occurring during the raining season. It therefore had a representation of 3(6%), land degradation 10(19%), water problems 5(9%), noise due to machines used 8(15%), and destruction of vegetation had a

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frequency of 4(7%). Household heads lamented on the rate at which children of school going dropped out of school because of the activity and that had a frequency of 11 being the highest problem representing 20%. Social vices, such as alcohol drinking and smoking, got a frequency of 6(9%) while poor sanitary conditions got 1 (2%), and dust had a frequency of 7(13%)

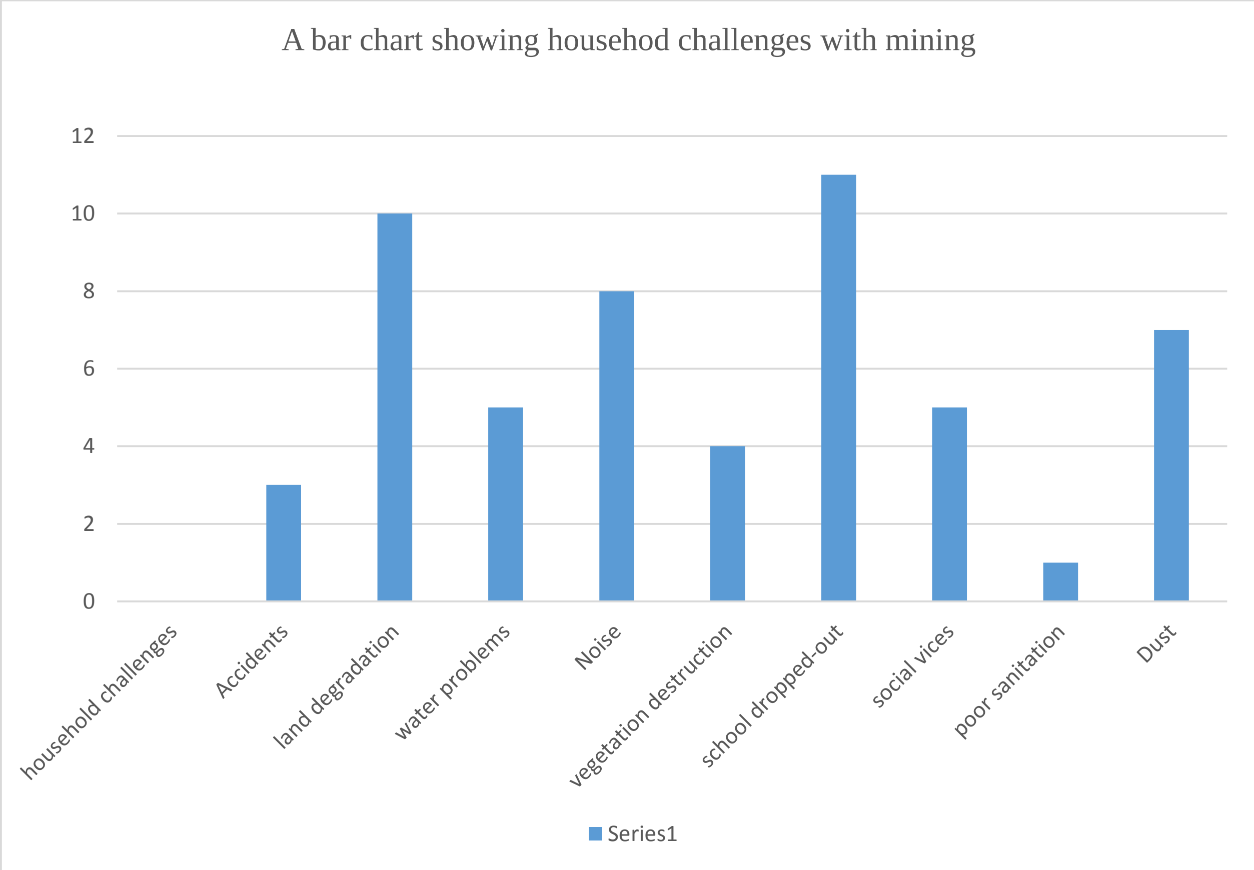

Figure 4.29: Challenges facing households against coping strategies

Source: Field survey, 2017.

As part of mitigating measures to deal with the health effects of mining in the community, both miners and households have adopted some mitigating measures to deal with the effects in their lives. From Figure 4.30, both miners and household heads have to wear protective clothing at some point in time in the community. From a total of 152 respondents, protective clothing had a frequency of 23 representing

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15%, some respondents said they had to stop working when it is raining also representing a frequency of 40(26%), others resort to buying mosquito coils/spray 24(16%), a frequency of 15 representing 10% sleep in treated bed nets whiles majority of respondents rely on Anglo-Gold Ashanti (Aga-mal anti-malaria spraying exercise) resenting 49(32%) and finally 1 (1%) go for medical checkups regularly.

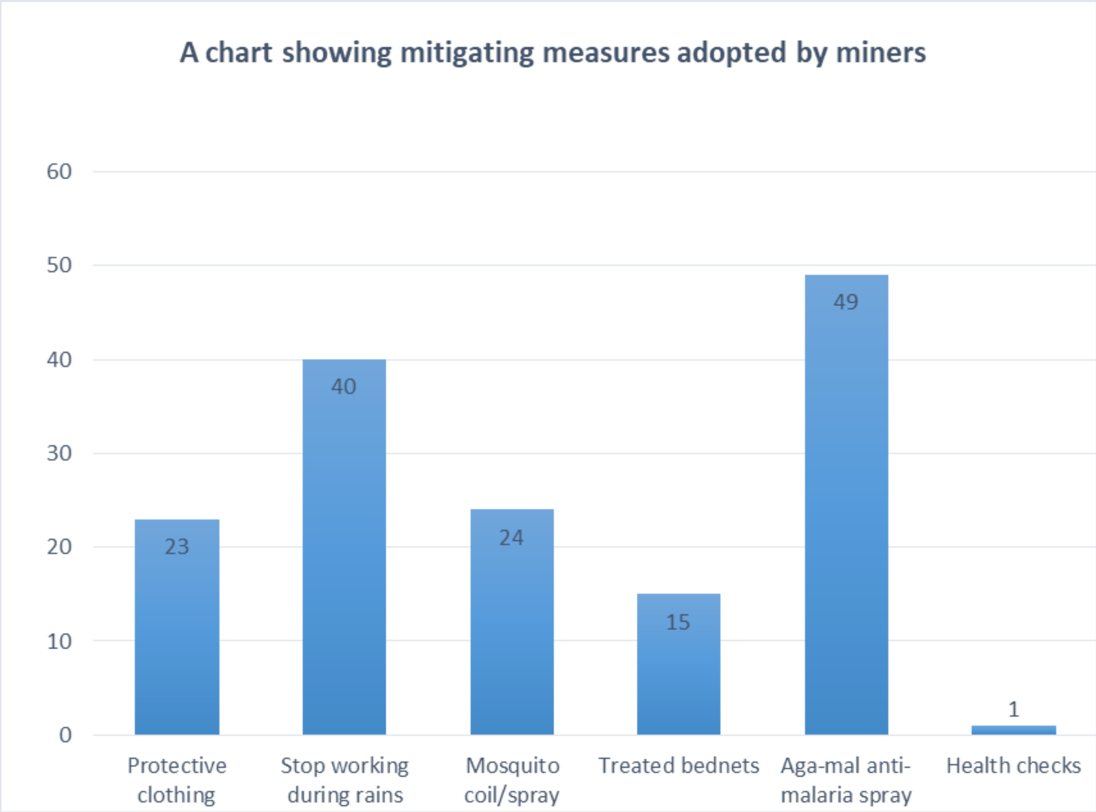

Figure 4.30: Measures for mitigating health effects of mining

Source: Field survey, 2017.

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CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study examined the environmental and health implications of artisanal gold mining in the Upper East Region with particular reference to Kadema in the Builsa North District. The objectives of the study included: to examine the nature of ASGM practices in Kadema, to ascertain the impact of artisanal mining on the environment, to assess effects of artisanal mining on the health of people and to examine households coping strategies to the negative effects of artisanal mining. This chapter presents the major findings, conclusion and recommendations.

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5.2 Summary of Major Findings

5.2.1 Nature of ASGM Practices

Artisanal gold mining practices in Kadema is quite different from other mining practices across the globe though people from all works of life travel to the community in to make ends meet. From the analysis, it was realized that miners were not only natives, some came from other districts. It was noticed that some natives do not require any form of permit or land acquisition because they feel they are the owners of the area and on the other hand, non-natives do require some form of permit and land acquisition though it is not obligatory for such in the mining site. They go to available institutions to undertake such requirement including traditional authority (chiefs, opinion leaders, land owners, etc.) and family heads. Some could not tell where permit and land is acquired before because they felt it was a secret to them. Miners, who secure for lands and permits for the operations, do it in the form of cash payment, animals (goat), some are only asked to contribute when there is an activity on-going in the community or if there is a funeral or festival. Some even donate the mined stones to these individuals to process themselves whiles others do not just pay anything at all.

For miners, they prefer to mine between January-March and October-December, because these are dry season periods and there is no farm work during these periods. They also mentioned that the risk at these periods are very minimal especially with regards to collapse of underground pits and that from April-June and July-September it is usually associated with heavy rains and storms which could be dangerous. Some also said they do not work during these periods because they need to engage in agricultural works and that is the reason for their choice.

It was realized that women especially are those working during these periods because mining pits have been left vacant, they go round these pits to collect soils for processing. From the study it was also realized that the most preferred methods of mining in the community is mostly underground and surface mining. For underground, it was realized that men are those engaged in it because it requires a lot of physical strength whiles surface mining is done mostly by women and some few young boys who cannot undertake the underground mining. Regarding mining activities in the community, a committee has been set up in the mining site to take charge of activities and to guide new miners on the various procedures before settling at the community to mine and therefore the committee report every issue to the chief and assist if there need be.

For surface mining, it was revealed that it does not require digging. Soils are collected around underground mining pits, dried, and grinded before it is washed whiles others will gather and start to wash straight ahead. From all these small stones are gathered,

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grinded/pounded and washed in addition. This is what the miners call 'DIG and WASH' or 'DOME-DOME'. For underground mining, miners will usually survey the land first and take a sample for trials and when it proves then they go to inform their colleagues to start the process of digging. Usually, miners will dig up to 100 m underground and it also requires some blasting when it becomes necessary. Both underground and surface miners do the activity in groups ranging from 3 – 20 people. These groups could contain relatives such as brothers, sisters, cousins, sons, daughters, fathers and mothers. Underground miners after gathering the stones sends them for grinding. First stones are grinded roughly and then smother with two different grinding machines. Water is collected from a distant dam to the mining site for washing. From the analysis it was realized that gold washing is not than closer to any water body in the community; rather everything is done at the mining site. During the grinding process, the site produces a lot of noise as well as dust and that has affected very few individuals with various health alignments. After the mining, artisanal miners do not reclaim lands because they hope to return some day after a period of time. The tools/equipment or materials miners use in the process in the process include; hammer, shovel, chisel, donkey-cart, blanket, bucket, sieve, bowl, washing board, pick-axe, hoe, head pan, cutlass, touch light, motor and pistil, grinding mill ('chanfine"), a rope, grinding mails.

It was also revealed that the various process miners under take before mining include:

- Self-introductory to the mining committee and community (this committee will lead you to the family head, or the assembly person then you are led to the chief for an official introduction) one at that point will state the intentions to the committee and others;

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- Permit and land acquisition (for both natives and non-natives though non-natives require it more than the natives). At this point community values are told and one is obliged to obey irrespective of your race;
- The individual will find a group to join or form a new one if he/she wants;
- Surveying the land;
- Soil sample is tested;
- Land preparation/clearing;
- Digging underground. stones and sand is collected and grinded/pounded;
- Transporting and loading;
- Washing equipment are set-up and water gotten from the dam to start the washing process (washing sometimes is done during rains. Miners stand by road side to wash soils from running water whiles others harvest water for later usage);
- Amalgamation process that is using mercury to separate gold from soil and water;
- Refining (Heating and scaling); and
- Payments issues thus buying and selling.

It emerged from the analysis that the mining site/committee does not have peculiar beliefs or norms pertaining to the mining area though community leaders adhere to decent behavior.

It was also notice that miners are not working for any corporate entity but for themselves and as well the majority is not aware of the precious mineral marketing corporation and therefore makes the sale of the gold at the site. Some individuals have become gold businessmen and therefore stay in the community to buy gold. Some

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individuals will travel to other locations outside the district to make their sales. These locations include the regional capital and some other places. The dug gravels (wastes) are stockpiled and re-handled by women, women carry the mine load to the washing plants for processing. To save the cost on disposal and material re-handling and reclamation, waste materials from the sources are stockpiled close to the pits

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5.2.2 Impacts of Artisanal Mining on the Environment

One of the leading effects of artisanal mining on the environment is soil degradation and land destruction. Mineworkers do not refill the holes they make after mining activities in the community. Pits are abandoned after mining is done. As a result, these open mine pits become traps for humans, animals as well as breeding grounds for mosquitoes. This therefore does not support plants growth around the area. Though it was realized that miners do not fell trees in the landscape, it was evident that the vegetation hampered miners and they need to clear the land area in other to excavate the gold underground. This destroys young trees that are still growing and leaves the land unsupportive for plant growth. It was also evident that mining in the Kadema community has paved way for soil erosion and thus reducing farm land availability in the community because degradation has claimed acres of lands and that cannot be used for any productive purposes especially agriculture.

Forest wetlands have high biological range and institute complex ecological units. They play several roles in conserving the stability of forest ecosystems in terms of groundwater recharge and discharge, flood control, sediment and toxicant retention, nutrient retention, biomass export, wildlife resources, fisheries resources and water supply (Dugan, 1990). The disruption of this equilibrium will have huge environmental consequences, particularly the destruction of the habitat of some animals that lives in these forest swamplands and has a declining populace due

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to hunting and falling in underground mining pits. Mining in the Kadema has produced large quantities of sand as well as mud. These are transported downstream and lead to the sedimentation of dams and are likely to cause forest wetland floods, which is harmful to aquatic life. It was realized that the activities have affect human life as the water source in the community is not portable. The increasing nature in the number of miners will ultimately increase the environmental risks in the community. The extent to which lands are degraded will push some individuals to acquire lands elsewhere and that will mean that more deforestation and degradation will occur thereby leading to climate change effects globally. Wildlife that used to be in the area have all moved because their habitats have been destroyed and even domestic animals are threaten because of their constant falling in pits rendering most losing their lives.

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5.2.3 Effects of Artisanal Mining on Health

Artisanal Small Scale Gold Mining is generally characterized by a lack of occupational safety. When asked whether they usually have accidents in the course of mining, responses were that wounds from the sharp tools such as cutlasses, spades as well as from blasters among others that they use. Other accidents stated by miners included many and underground pit collapse with the risk of covering them in soil underground especially during the wet season. The risk of pit collapse was reported to be severe since holes generally do exceed 100 m in depth. Miners know that artisanal gold mining is a risky activity and some miners said they have witnessed deadly accidents in the past.

Exposure to wild animal attacks is also a risk that miners and households reported they face every day especially scorpion and snake attack. These reptiles attack is mostly frequent in the rainy season where grasses are grown. For them in the community, they do take particular safety measures such as wearing protective clothing when roaming at the site. Malaria, typhoid, catarrh, dislocations, waist pains, cardiovascular problems as well as asthma and cholera are some of the diseases people face. Uncovered mined pits have become breeding places for mosquitoes and that has caused an increase in malaria cases in the communities from records of the health center as compared to precious years when the activity was not done. The health officer also indicated that they has been several emergency cases due to collapse of pits and Blasters attack from the mining site though most of these cases are often referred to big facilities though some on arrival do loss their lives.The constant grinding of soils and stones usually produce dust and noise where some few respondents testified that they have become asthma patients because of the dust they have been inhaling during the grinding process. The hard nature of the activity also involves a series of vigorous strength where some indicated that they usually have waist and body pains.

Quite apart, the district assembly and Ghana Health Service have provided various supports to people in the community such as constructing CHPS compound. Though some residence have been enrolled in the NHIS, some are yet to. They have constantly provided free health screening as well as immunization of early childhood killer diseases to children in the community. Community health workers have constantly made home visitations talking about issues of health and sanitation. There have also been other major campaigns that the assembly and Ghana Health Service have organized to sensitize members in the community especially miners and households on reproductive health, malaria control and prevention, disease control and prevention as well as family planning.

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On the issue of how miners and household seek for medical care, it was mentioned that they visit health centers with the majority of people though some seek for herbal treatment because they cannot afford for hospital bills, others rely heavily on drug stores whiles the least of people seek self-medication.

5.2.4 Households Coping Strategies to the Negative Effects of Artisanal Mining

From the analysis it was realized that households have constantly suffered from mining activities in the community and have developed alternative livelihoods and other mitigation measures to handle the challenges they are faced in the locality. Accidents have been occurring because of uncovered underground mining pits, both human beings and animals. Some became severely injured and animals died in these pits whiles some humans got several injuries. Noise and dust are challenges that are very worrying because of the grinding machines and sometimes the blasting and pounding.

There has been land degradation causing erosion in the area and lands cannot be used for any agricultural activity. Coming to talk about school children, majority has left school for the activity because they feel that is the easy way to make money. Some have also join the activity because they want to get some form of money to pay for their school bills and be able to buy books, pens, etc. In all these, it is not helping the children in terms of their academic work. Some as a result of joining the activity are found in social vices such as alcohol drinking and smoking. Some have even become arrogant and disrespectful because they feel they are financially stable. It is also worrying to know that sanitation issues in the locality are questionable because a lot of activities are on-going. Water systems have been affected and some have to walk far distances to secure some form of portable water for drinking. The sources of water

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found in the community include boreholes, well, dam and others (rain water). In using these sources, households have to undergo some form of water purification/treatment before using it. Those who are financially capable have been able to connect to GWCL (Ghana Water Company Limited) to secure water. Those who are not able to connect have to improvise ways to get good/clean water for their domestic uses. Naphthalene (camfer) is usually dropped in water by some households for killing germs in the water. Majority of the households have resorted to buying water for use whiles those using wells have provided a lid/covering to protect the source from any source of contamination. Some few households have also constantly harvested rain water for use during the rainy season.

With agricultural farmlands, some households have acquired new lands for their agricultural purposes because those lands that are destroyed cannot be used for anything. Some have constantly applied fertilizer/compost to their available farmlands because farmlands have evenly lost the soil fertility and cannot support any plant growth. Therefore, farmers have to secure this means to support the plant growth. Few gardens have been established by some few individuals in the community. Though some households have moved elsewhere to establish new farmlands to supplement the fewer ones available, especially those of the forest lands, nothing is done on issues concerning the vegetation in the area. Sensitization/education is ongoing on appropriate ways of mining which is usually done by the District Assembly and some few household heads who are constantly engaged in these activities. However, some few moringa seedlings are being transplanted around various households as well as some few economic trees like mango and others. Some are also not doing anything about the vegetation because they do not know what to do and that they are just relying on God.

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Quite apart, various mitigation measures have been adopted to deal with the health effects emanating from the mining activities. Due to the accidents that kept occurring in the community because of the uncovered mined pits individuals have decided not to work or walk around the mining area in other to avoid chances of falling into the pits. Protective clothing has constantly been worn to avoid snake and scorpion bits in and around the site and community at large. As a result, some households have purchased what they call 'Magic chalk' which is to be used in the event of any of these reptiles' attack. Households have annually benefited from Aga-mal anti-malaria spraying exercise and as a result has kind of reduced malaria complains at health centers whiles others resort to buying mosquito coils/spray and sleeping in treated mosquito bed nets to avoid being bitten by mosquitos that will cause malaria. Finally, few ones in the community consult health facilities for medical checkups.

Some miners said they were satisfied with the income earned from mining. Some of those who were not satisfied with the income from mining were people who were not working in mining on a full-time basis. They were people who engaged in other activities as well as those of the various households these activities include farming and trading. Some people also carried out mining to substitute and supplement income from other sources. From the analysis, households developed alternative livelihoods as a way of supporting themselves because of the mining. Some these activities include, picking of NFTP (Non-Forest Timber Forest Product) such as dawadawa, baobao, tamarine and shea nuts. In all these products, food is obtained and extra income is made from the sales of these products. Some have also resorted to food vending at the mining site, especially women. Daily, the site gets people working and needs food to eat in other to work as a result households have decided to sell food to those working in and around the site and even people outside. They have also

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established drinking bars (beer bar). Some have engaged in labor work especially during farming seasons. They assist people on their farm lands and they are usually paid for their works. Others are into mechanic work such as bicycle and motor fitting and other related works. Women especially engage in shea and dawadawa processing. They use these products at home and sometimes sell them to generate income to support other household works.

Animal rearing has become an activity for most men in the community. They use these animals when it became necessary especially during economic crisis whiles others have established provision shops in the area and lastly some have acquired jobs as civil servants in government institutions as well as those in the private institutions.

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5.3 Conclusion

The purpose of the study was to examine the environmental and health implications of artisanal gold mining with particular objectives of examining the nature of artisanal gold mining, the environmental implications of gold mining, the health implications of artisanal gold mining and, household coping strategies to the negative externalities of artisanal gold mining. From the study conducted the researcher realized that miners in Kadema have to do some form of community entry and registration before mining at the site though it is often expressed verbally. It is very significant to the community leaders and the mining committee since one need to make some form of contribution to the community if the need be. The researcher has also found out that the most peculiar chemical that is being used by the miners in the community is mercury which gold buyers usually supply them.

Come to talk about the impact on the environment, it was find out that lands are not reclaimed because miners have the intention of returning to those areas at some point

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in time rendering those parcels of land unproductive for agricultural activities. These have resulted to a lot of soil erosion and land degradation at the vast land though those areas that are being destroyed by the mining activities cannot support any plant life and therefore reducing the vegetative cover of the area. It was also realized that the only water source for domestic use at the community has broken down though water quality test was conducted by the researcher to ensure that mining activities have not affected the only source but it was unfortunate the test results showed that water was not good for consumption since parameters were above the WHO standards. It also was also noticed that not only miners suffer the major health challenges from the mining activities but households as well. It was realized that individuals lost their lives because of pit collapse and some falling in the underground pits as well as animals; some were bitten by snakes, scorpions and other wild animals. The noise and dust has rendered some individual asthmatic whiles a lot suffered from malaria because of constant stagnant water in the community. Various illness and physical health issues have been recorded including broken legs and others.

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However, households developed some alternative livelihoods because of the activity as well as some coping strategies to deal with health, environment as well as their livelihood. It was interesting to note that some of these alternative livelihoods include NTFP such as shea, dawadawa, and baobab harvesting. Other strategies were adopted to deal with health issues.

5.4 Recommendations

- The Builsa South District Assembly should establish environmental responsive mining practices trainings and follow-ups made to check the mining practices. Sanctions can therefore be forced on defaulters.

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- Government impose Taxes should be imposed on artisanal miners.
- Government/ NGOs make Motivation/compensation should be made available to miners who carry out the best mining practices. This will thus inspire several more to follow.
- District Assemblies as well as private individuals should Teach sustainable artisanal mining methods to alleviate the undesirable environmental effects that mining creates;
- Government can Generously, give them technical aid by carrying out prospection and assigning areas for artisanal gold mining accomplishments;
- Individuals, NGOs and government institutions should construct A well stock health center responsible in dealing with health issues around mining accomplishment
- Government and private organizations should create forums where miners are taught financial management and diversification of their activities that can lead some miners leaving mining and taking up an alternative activity.
- The District Assembly Should Facilitate procedures for obtaining artisanal mining permits. This will lead to a formalization of the sector and regularize many miners
- There is no sole key for the environmental, health, household coping strategies, and technical problems associated with ASGM. Nevertheless, a lifelike tactic should reflect improving the level of tutoring of miners, constructing government programs to offer practical support in the field, streamlining managerial processes and safeguarding adequate actions for implementation.

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5.5. Gaps for Further Studies

- The end - uses of reclaimed lands in artisanal gold mining.
- Perspectives on teenage involvement in artisanal small scale gold mining.
- Artisanal small scale gold mining land reclamation, the foundation to ecological performance and sustainability.

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APPENDIX

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FACULTY OF INTEGRATED DEVELOMENT STUDIES

DEPARTMENT OF ENVIRONMENT AND RESOURCE STUDIES

Questionnaire for miners

Introduction:

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The purpose of this study is to fulfill the requirements for the award of Master of Philosophy Degree in Environment and Resource Management, at the Department of Environment and Resource studies, University for Development Studies. The study solicits for data in order to examine the environmental and health implications of artisanal gold mining in Kadema in the Builsa North District. You are assured that responses given will be treated with confidentiality and will be used solely for academic purposes. Kindly answer the questions as objectively as possible.

Thank you.

Section A: Background information

Kindly tick as [√], where appropriate and please provide responses where necessary.

A. Personal Information

1. Indigene [ ] 2. Non-indigene [ ]

2. Sex…. Male [ ] Female [ ]

3. Age…......

4. Occupation……………….. …

5. Marital status: a. Married [ ] b. Unmarried [ ] c. Divorced [ ]

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6. Highest level of educational attainment

a. No formal education [ ]

b. Basic [ ]

C. secondary (S.S.S, Training College, Vocational) [ ]

d. Tertiary (Polytechnic, University) [ ]

e. Others, specify

7. For how long have you been staying in this town/village?

a. ……years

b. ……months

c. ……..weeks

d. ……..days

B. How is ASSGM practiced in Kadema

8. what method(s) of extraction is/are used by the miners? (Tick all that apply)

A. Surface Mining

B. Underground Mining

C. Dredging

D. Gallamsey Method

E. Other, specify……………………………..

9. How long have you been in mining activities?

   a. less than a year

   b. 1-3 years

   c. 4-6 years

   d. 7 – 10 years

   e. Over 10 years

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10.Did you acquire any permit before mining at the site?

Yes [ ]

No [ ]

11.If yes which institution/individual did you obtain permit from?

a. Traditional authorities

b. Local government

c. Family head

d. No authorized permit acquired

e. Others (specify)…………………

12.How much did you pay (cash/kind) for permit?………………………………..

13. Did you acquire any land before mining at the site?

Yes [ ] No [ ]

14. If yes which institution/individual did you obtain land from?

a. Traditional authorities

b. Local government

c. Family head

d. No authorized land acquired

e. Others (specify)…………………

15. How much did you pay (cash/kind) for land?………………………………..

16. Are you working for a corporate entity?

Yes [ ]

No [ ]

17. If yes to (Q.16), what is the name of the entity?………………………………

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18. Do you belong to any miners group or association in the community?

Yes [ ]

No [ ]

19.If yes to (Q.18) how many are you in the group?

1 -5 [ ] 6-10 [ ] 11 – 15 [ ] 16 – 20 [ ] above 20 [ ]

20.Do you have other relatives helping you in the mining activities?

Yes [ ]

No [ ]

21.If yes to (Q.20), how many are they?..............

22.How are you related to them

Brother [ ] Sister [ ] Son [ ] Daughter [ ] Cousin [ ] others (specify)……

23.What tools/ equipment do you use in mining? ……………………………………

24. Do you mine all year round?

Yes [ ] No [ ]

25. IF No (Q24) Which period is most preferred to you for mining?

January-March [ ] April-June [ ] July-September [ ] October-December [ ]

Why that specific period?

26. List the activities you undertake during in the mining

A. Land clearing

B. Digging

C. Hauling

D. Washing

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E. Blasting of the gold ore

F. Crushing of the gold ore

G. Chiseling

H. Others (specify)………………………

27. What chemicals do you use in the mining activities?

A. Mercury

B. Arsenic

C. Cyanide

D. Others (specify)…………………………..

28. What is your source of water for washing gold materials?

A. River

B. Dam

C. Stream

D. Others (specify) …………..

29. Where do you wash the gold materials?

A. Inside the water body

B. At the banks of the water body

C. 500 m away from water body

D.1 km away from water body

E. More than 1 km

30. Can you describe how the gold in extracted or process?

31. How do you dispose the mining waste materials after final gold extraction?

32. Are you aware of the precious minerals marketing cooperation?

Yes [ ] No [ ]

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33. If no (Q.32) who are the buyers of your products?

34. Where do you sell the products?

A. At site

B. District capital

C. Other towns …………………………………

35. Do you do any land reclamation on the site of mining? Yes [ ] No [ ]

36. If no (Q.35) why don't you do it?

37. What other occupation do you engage in aside the mining? ……………………

C. Impact of the mining operations on the natural environment?

38. Do you think the methods of operation have some effects on the natural environment? Yes [ ] No [ ]

39. If yes, what are some of the effects? (Tick all that apply)

A. Degradation of land and vegetation

B. Water pollution

C. Air pollution

D. Noise pollution

E. Other, specify …………………………….

40. What actually cause(s) land degradation? (Tick all that apply)

A. Presence of tailing dams

B. Use of toxic materials

C. Use of heavy machines

D. Clearing of Vegetation

E. Long period of extraction

F. Other, Specify……………………………………………………………………

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41. What cause(s) pollution on the environment? (Tick all that apply)

A. Presence of tailing dams

B. Use of toxic materials

C. Use of heavy machines

D. Clearing of Vegetation

E. Long period of extraction

F. Other Specify…………………………………………………………………

43.Can you estimate the total land area you clear as an individual in a year for mining purposes…………………………..

44. In your own opinion do you think your mining activities have any effects on the vegetation and land of the community? Yes…………… No……………

45. If yes to (Q.44) what are some of the effects?

A. Loss of tree/shrub species diversity

B. Loss of tree/tree species abundance

C. Exposure of soils to erosion

D. Removal of top soil

E. Others (specify)……………………….

46. Do you think your activities have any effects on the water bodies of the community?

Yes [ ]

No [ ]

47. If yes (Q.46) what are some of the effects on water bodies?

A. Siltation of water bodies

B. Pollution of water bodies

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C. Poisoning of aquatic animals

D. Excessive pressure on available water resources

48. Do live at the mining site? Yes [ ] No [ ]

49. Does ASSM have any impact (Pollution) on surface and ground water? YES ( ) NO ( )

50. If yes or no explain your answer

51. Has ASSM contributed to soil contamination by heavy metals such as (Mercury)?

52. Has it affected farm land availability (Decrease)?

53. Has ASSM related activities brought disturbances such as noise?

C. How has the operations affected the health of people?

54. In your own opinion do you think the mining activities have any health effects on the people living in the community?

    Yes [ ]

    No [ ]

55. If yes, what are some of the health effects/ailments

56. What are some of the hazards you face as a mining worker?

    Yes [ ]

    No [ ]

57. Mention type of injury recorded…………………………………………….

58. Which of the following diseases do you usually suffer from or contract?

    A. Malaria

    B. Diarrhoea

    C. Skin diseases

    D. Fever

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E. Colds and catarrh

F. Other disease(s) ………………………..

59. What diseases do people in your family frequently contract?

A. Malaria

B. Diarrhea

C. Skin diseases

D. Fever

E. Colds and catarrh

F. Other disease(s) …………………………….

60. Would you say the disease(s) chosen above are related to the mining activities?

Yes [ ]

No [ ]

61. Where do you seek medical care to address your health needs?

A. Clinics

B. Hospitals

C. Traditional (herbal) medicine

D. Drug stores

E. Other, specify ………………………………

63. Has there been anything to address the health needs of the community?

Yes [ ] No [ ]

64. If yes, what are some of these activities?

64. Has there been any health campaign programs to educate people in the community about the effect of mining? Yes [ ] No [ ]

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65. If yes, give any example of such campaigns you know of and the name of the organization that organized.

D. How are households coping with the negative externalities of ASSGM?

66. How are you coping with the impact of the mining activities on the following natural resources?

    A. Water bodies

    B. Agricultural lands

    C. Vegetation

67. Do you have any measures for mitigating the health effects of the mining activities on your household?

    Yes [ ]

    No [ ]

68. If yes mention some of the mitigation strategies you have adopted

69. Are there any bye laws in the community to govern the activities?

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QUESTIONNAIRE FOR HEALTH WORKERS

Section A: Background information

Kindly tick as [√], where appropriate and please provide responses where necessary.

A. Personal Information

1. Workplace (Name Clinic/Hospital)………………………………

2. Sex…. Male [ ] Female [ ]

3. Age…......

4. Department/Position………………………..……………….. …

5. Highest level of educational attainment a. Illiterate [ ] b. Basic [ ] c. Secondary (S.S.S, Training College, Vocational) [ ] d. Tertiary (Polytechnic, University) [ ] e. Others, specify

6. Which of the following diseases are frequently reported and diagnosed at the Hospital/clinic? (Tick all that apply) A. Malaria B. Diarrhea C. Skin diseases D. Fever E. Colds and catarrh F. Injuries G. Other disease(s) ……………………

7. Which of the diseases mentioned above tops the chart for the past three years? A. Malaria B. Diarrhea C. Skin diseases D. Fever E. Colds and catarrh F. Injuries G. Other disease(s)…………………………………………………………..

8. Are some of the sicknesses directly or indirectly associated with mining activities? Yes [ ] No [ ]

9. If yes, which of the sicknesses are caused by or associated with mining activities within kadema? (Tick all that apply) A. Malaria B. Diarrhea C. Skin diseases D. Fever E. Colds and catarrh F. Injuries G. Other disease(s)………………

10. Do the sicknesses mentioned above constitute a significant cause in mortality rates in the communities? Yes [ ] No [ ]

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11. Is your clinic/hospital fully armed to handle such cases frequently reported at the hospital/clinic? Yes [ ] No [ ]

12. If no, what are the constraints?

13. Is the health sector doing anything possible to address the health problems associated with mining activities within the District? Yes [ ] No [ ]

If yes, what are some of the measures?

14. Are miners themselves doing anything to address the health needs of the community? Yes [ ] No [ ]

15. If yes, what are some of these activities?

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QUESTIONNAIRE FOR STAFF OF DISTRICT ASSEMBLY

Section A: Background information

Kindly tick as [√], where appropriate and please provide responses where necessary.

A. Personal Information

1. Sex…. Male [ ] Female [ ]

2. Age….......

3. Department/Position…………………………..……………….. …

4. Highest level of educational attainment a. Illiterate [ ] b. Basic [ ] c. Secondary (S.S.S, Training College, Vocational) [ ] d. Tertiary (Polytechnic, University) [ ] e. Others, specify

B. **Mining Activities and Impacts on the Environment**

5. What method(s) of extraction is/are used by the niners? Tick all that apply

A. Surface Mining B. Underground Mining C. Dredging D. Gallamsey Method E. Other, specify……………………………...

6. Do you think the methods of operation by the miners have some effects on the natural environment? Yes [ ] No [ ]

7. If yes, what are some of the effects? (Tick all that apply) A. Degradation of land and vegetation B. Water pollution C. Air pollution D. Noise pollution E. Other, specify …………………………….

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8. What actually cause(s) land degradation? (Tick all that apply) A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines D. Clearing of Vegetation E. Long period of extraction Other, Specify…………………………

9. What cause(s) pollution (of any sort as chosen in Q8) on the environment? (Tick all that apply) A. Presence of tailing dams B. Use of toxic materials C. Use of heavy machines D. Clearing of Vegetation E. Long period of extraction

F. Other, Specify…………………………………………………………………

10. Has the assembly made attempts to reduce the adverse environmental effects of mining activities? Yes [ ] No [ ]

11. If yes, what are some of the measures being undertaken? A. Re-afforestation B. Resettlement of affected communities C. Providing alternative sources of drinking water D. Compensation to affected communities E. Reviewing or varying methods of operation F. Others, specify …………………………………

12. Are the efforts at reducing the environmental impacts satisfactory and effective? Yes [ ] No [ ]

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C. **Mining and Health**

13. What are the sources of medicine to address your health needs? A. Clinics B. Hospitals C. Traditional (herbal) medicine D. Drug stores E. Other, specify ……

14. Give reasons for your answer in Q13

15. Is the district assembly doing anything to address the health needs of the community? Yes [ ] No [ ]

16. If yes, what are some of these activities? 17. Has the district built any health facility in this community for the service of both workers and people in the community? Yes [ ] No [ ]

18. Does the assembly carry out any health campaign program to educate people in the community? Yes [ ] No [ ]

19. If yes, give any example of such campaigns you know of

D. Roles of the District Assembly and Other Regulating Bodies

20. How is the District Assembly's relationship with mining community?

A. Very cordial B. Cordial C. Bad D. Very bad

21. Does the Assembly undertake steps to check and address the adverse environmental and health effects of mining activities? Yes [ ] No [ ]

22. If yes, what are some of the measures? 23. Are the following Agencies monitoring and assessing the environmental and health impacts of mining activities in this community? A. EPA Yes [ ] No [ ] B. Ghana Chamber of Mines Yes [ ] No [ ] C. Ghana Minerals Commission Yes [ ] No [ ] D. Lands and Forestry Commission Yes [ ] No [ ] E. NGOs Yes [ ] No [ ]

24. Which of these agencies are very active? (Tick all that apply) A. EPA B. Chamber of Mines? C. Ghana Minerals Commission D. Lands and Forestry Commission E. NGO's (Name…………………………………………………………)

24. Would you say that these agencies are doing well in monitoring and assessing mining activities? Yes [ ] No [ ]

25. Give reasons for your answer

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QUESTIONNAIRE FOR HOUSEHOLD HEADS

Section A: Background Information

Kindly tick as [√], where appropriate and please provide responses where necessary.

1. Sex of respondent 1. Male [ ] 2. Female [ ]
2. Age of respondent [ ]
3. What is your family size? ………………….
4. Educational level of respondent 1. None [ ] 2. Primary [ ] 3 Middle/JSS [ ] 4 Secondary/SSS [ ] 5. Tertiary [ ]
5. What is your main source of income? 1. Farming [ ] 2. Fishing [ ] 3. Trading [ ] 4. Civil/public servant [ ] 5. Galamsey [ ]
6. Religion of respondent 1. Christian [ ] 2. Muslim [ ] 3. Traditionalist [ ] 4. Other specify………………………

Section B: The Nature of ASSGM Mining Practices in Kadema

1. Do you have any idea about mining activities in this town/village?
   a. 1. Yes [ ] 2. No [ ]

7. If yes, what method(s) of extraction is/are used by the miners? (Tick all that apply)
   b. 1. Surface Mining [ ] 2. Underground Mining [ ] 3. Dredging [ ]
   c. 4. Gallamsey Method [ ] 5. Other specify……………………………..

2. Can you identify the activities miners undertake during the mining?
3. What chemicals do miners use in the mining activities?
   1. Mercury [ ] 2. Lead [ ] 3. Arsenic [ ] 4. Cyanide [ ] E. Others (specify)…………………………..
4. Describe how the gold is extracted by the miners?

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5. What problems do you household face with respect to the practice of gold mining practice?
6. In what way(s) do your household hope to improve the activities to overcome the above problems?
7. How is your household coping with the processes of gold mining?
8. In your own view, what services or support do your household need to enhance the mining practice…………………

Section C. The Impact of the Mining Operations on the Natural Environment

1. How severe are the impact of this method of operation by the miners on the natural environment? 1. Very severe [ ] 2. Severe [ ] 3. Not severe [ ]
2. Which of the following can be affected by this method of operation? (Tick all that apply)
3. 1. Degradation of land and vegetation [ ] 2. Water pollution [ ] 3. Air pollution [ ] 4. Noise pollution [ ] 5. Other, specify ……………………………
4. Can you estimate the total land area miners clear as an individual in a year for mining purposes…………………………..
5. In your own opinion do you think mining activities have any effects on the vegetation and land of the community? 1. Yes [ ] 2. No [ ]
6. If yes to (Q.31) what are some of the effects?
7. Loss of tree/shrub species diversity [ ] 2. Loss of tree/tree species abundance [ ] 3. Exposure of soils to erosion [ ] 4. Removal of top soil 5. NA [ ]
8. If yes what are some of the effects on water bodies.
9. Siltation of water bodies [ ] 2. Pollution of water bodies [ ] 3. Poisoning of aquatic animals [ ] 4. Excessive pressure on available water resources

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10. What is your source of water for livelihood activities?

11. Has the activities of the mining affected your household source of water?

Yes [ ] No [ ]

12. What are your coping strategies to your household source of water?

13. Does ASSM have any impact (Pollution) on surface and ground water?

1. Yes [ ] 2. No [ ]

14. If yes how and if no why

15. Has ASSM contributed to soil contamination by heavy metals such as (Mercury)?

Yes [ ] 2. [ ]

16. If yes how and if no why

17. Has it affected farm land availability?

18. 1. Yes [ ] 2. No [ ]

19. Has ASSM related activities brought disturbances such as noise?

20. 1. Yes [ ] 2. [ ]

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Section D: Impact of ASSM on the Health

1. In your own opinion do you think the mining activities have any health effects on the people living in the household? 1. Yes [ ] 2. No [ ]
2. If yes what are some of the health effects
3. How does your household cope with the health effects of the mining activities?
4. Which of the following diseases do you or members of your household usually suffer from or contract?
    1. Malaria [ ] 2. Diarrhoea [ ] 3. Skin diseases [ ] 4. Fever [ ] 5. Colds and catarrh 6.Other disease(s) ………………………..

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5. Would you say the disease(s) chosen above are related to the mining activities?

   Yes [ ] 2. No [ ]

6. Where do you seek medical care to address your health needs?

   a. 1. Clinics [ ] 2. Hospitals [ ] 3. Traditional (herbal) medicine [ ] 4. Drug stores [ ]

   b. 5. Other, specify ………………………………

   c. Has there been anything done to address the health needs of the community/household? 1. Yes [ ] 2. No [ ]

7. If yes, what are some of these activities?

8. 53. Has there been any health campaign programs to educate people in the community about the effect of mining? Yes [ ] No [ ]

9. 54. If yes, give any example of such campaigns you know of and the name of the organization that organized.

Section D. Households Coping with the Negative Externalities of ASSGM

1. How are you coping with the impact of the mining activities on the following natural resources?

   a. Water bodies
   b. Agricultural lands
   c. Vegetation

2. Do you have any measures for mitigating the health effects of the mining activities on your household? Yes [ ] 2. No [ ]

3. If yes mention some of the mitigation strategies, you have adopted?

4. Are there any bye laws in the community to govern the activities of miners?

5. How is your household coping with the impact of the mining activities?

6. What alternative livelihoods do you engage in as a result of the mining activities?

7. How often do you engage in these activities?

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