Mendel University in Brno
Faculty of Forestry and Wood Technology

The impact of illegal mining on forest ecosystem and stream water quality: a case study on river Birim, Ghana and a comparison with the situation in the EU

Diploma thesis

Brno, 2016. By: Bc. Eric Marfo Karikari

Mendel University in Brno

Faculty of Forestry and Wood Technology

Department of Geology and Pedology (FFWT)

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Dedication

I dedicate this thesis to my better half, Evelyn and my kids (Nana Yaw Kwarteng Karikari and Nhyira Antwi Karikari)

Acknowledgement

I am grateful to The Almighty God for establishing me from the start of the programme up to this point.

I would also like to express my sincere gratitude to my supervisor doc. Mgr. Jindřich Kynický, Ph.D. (Associate Prof.) for the indefatigable effort, guidance, encouragement, expert and sincere comments he offered me at all stages of my work. I am indebted to him for the valuable help he extended to me.

My sincere gratitude also goes Ing Kofi Ampadu Boateng for his immense contributions toward the realization of this work.

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Abstract

Illegal gold mining '*galamsey*' is an issue of utmost concern in modern day politics in Ghana if sustainable development is to be achieved. Mining for mineral in general can lead to a boom in the economy since it affects multiple disciplines. This phenomenon holds for both legal and illegal mining. There is a cost however associated with this economic boom. This thesis aimed at assessing the impact of illegal mining in forest ecosystems and stream water quality. The case study was on River Birim in Ghana and the trends were compared with the current situation within the European Union (EU).

The approach for this thesis was mainly a case study design. However, qualitative, quantitative as well as mixed methods were also adopted in the methodology. Data were collected from relevant sources and a set of questionnaires administered. In all, 270 sampled questionnaires were successfully administered out of the total population and were used in the analysis. Based on responses obtained from the respondents, field observation and supporting data available, it was noticed that illegal mining had an adverse effect on the surrounding communities. Some common negative effects of illegal mining identified were; depletion of natural resources, pollution of water bodies and destruction of ecosystems. It was deduced that water, though scarcely available within the EU was comparatively unpolluted and mining activities properly regulated.

As a recommendation, it was suggested that government, local authorities and stakeholders should increase efficiency in the regulation of small-scale miners and their activities in order to reduce the ill-effect of mining to surrounding communities and the country in totality.

Key words: ecosystem, water quality, sustainability, illegal mining, Ghana

Abstrakt

Nelegální těžba zlata zvaná "galamsey" patří mezi hlavní témata dnešních politiků v Ghaně, stejně jako témata dosažení udržitelnosti rozvoje. Těžba minerálů obecně může vést k velkému rozmachu ekonomiky, protože to ovlivňuje více odvětví průmyslu. Tento fenomén se týká jak legální tak i nelegální těžby. Tato seminární práce má za cíl zhodnotit dopad nelegální těžby na lesní ekosystémy a na kvalitu povrchové vody. Případová studie se týká řeky Birim v Ghaně a její stav je porovnáván se současnou situací v rámci Evropské unie (EU).

Přístup a koncept této seminární práce je na úrovni studije. Co se týká kvality a množství bylo při sběru dat použito hned několik metod. Data byla sbírána z relevantních zdrojů a zprocesováním několika dotazníků. 270 reprezentativních dotazníků tak bylo vyhodnoceno a zapracováno pro účely této studie. Na základě reakcí respodentů, vlastního pozorování a dalších dostupných údajů z databází bylo zjištěno, že ilegální těžba má jednoznačný negativní vliv na bezprostřední okolí zájmového území. Nejčastější negativní účinky nelegální těžbě jsou blíže specifikovány; vyčerpávání přírodních zdrojů, znečištění vodních zdrojů a fevastace ekosystémů jsou těmi nejvážnějšími. Závěrem vyvozuji, že i když v rámci EU není mnoho vodních zdojů, tak jsou v porovnání se situací v Ghaně v drtivé většině neznečištěny a veškerá těžební činnost je řádně regulována.

Jako doporučení bylo navrženo, aby vláda, místní orgány a zúčastněné strany zvýšili efektivitu regulace činnosti malých těžebních společností za účelem snížení nepříznivých účinků povrchové těžby na bezprostřední okolní, lesní ekosystémy a celkově životnímu prostředí Gnany.

Klíčová slova: ekosystém, kvalita vody, udržitelnost, ilegální těžba, Ghana

List of Abbreviations

ASM	Artisanal Small-scale Mining
CPP:	Convention People's Party
EEA: `	European Economic Area
EIA:	Environmental Impact Assessment
EU:	European Union
GSS:	Ghana Statistical Service
GDP:	Gross Domestic Product
HDI:	Human Development Index
IGF:	Internally Generated Funds
LI:	Legislative Instrument
NDC:	National Democratic Congress
NEAP:	National Environmental Action Plan
NPP:	New Patriotic Party
UNDP:	United Nations Development Programme
WHO:	World Health Organization
WFD:	Water Framework Directive

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I. Introduction

Illegal gold mining popularly called 'galamsey' has become a maniac in most communities in the Republic of Ghana with its perennial devastation of the environment. Illegal gold mining has come to stay among most of the unemployed youth and the aged in most of the mining communities. The activities of these miners are causing serious environmental havoc and destructions (Aryee et al., 2003; Akabzaa, 2001).

It is pathetic to note that not only the indigenes are involved in this illegal business but also the Chinese have managed their way into this environmentally destructive activity. According to Moyo (2012), the Chinese engagement is liberated from the moral-teaching and paternalistic role the West played in Africa when tying their aid to various political conditions such as economic reforms and increased democratization among others.

According to research by the mineral commission, in Ghana small scale gold mining is said to be responsible for about 5% of the annual gold production. However, this gold mining has become unpopular due to significant environmental impact seen in such areas (Hilson, 2002).

Ghana is indeed suffering from environmental impact of unmanaged activities of illegal mining. According to the Report Ghana (2012), about 28% of gold is produced in Ghana in a way that causes severe environmental problems.

One of such water bodies which have suffered enough contamination is River Birim, right from the source to my area of study, which are Kade and its surrounding communities.

Most communities in Ghana rely on streams and rivers bodies for livelihood, from drinking directly to other domestic usages. This buttresses the point that most of such communities in Ghana are cited near or closed to water bodies to ensure all year round supply of water for their use. Obiri (2007) purported that most of the surface water bodies in Ghana have become unwholesome for human use because of contamination with chemicals from illegal gold mining.

1.1. Main objective

This piece of work focuses on the impact of illegal gold mining popularly called '*galamsey'* on domestic water consumption and usage of River Birim at Kade and its surrounding communities where the river is their main source of water. It also highlights on the extent to which the environment and forest ecosystem are impacted by these illegal mining activities.

Lastly, a comparison will be made to the situation in EU to be able to establish the main differences.

1.2. Rationale

The rationale for choosing this topic is the fact that illegal gold mining activities have taken a centre spread in the newspapers of Ghana for quite some time now with the situation still compounding as the youth in these communities have embraced this business serving as their source of worth and causing detrimental effect to the forest ecosystem and to water bodies.

The researcher sees himself to be more or less affected by this mining activity since River Birim used to be a multipurpose river providing source of good drinking water, for swimming by indigenes and other water games. However, all these usages have been relinquished as a result of '*galamsey'* activities. Thus the researcher finds the topic interesting, as it can contribute to increased understanding of why more attention should be paid to sensitization programmes to encourage the youth to enter into more environmentally sustainable ventures.

1.3. Study area

This section will present some basic facts and history about Ghana, Kweabibirem District which Kade is the capital, the geography, climate and economic situation.

1.3.1 Geography and demography

Ghana is located in West Africa, about 400miles (644km) north of the equator, in the Gulf of Guinea, which forms 335miles (539km) of its south border. To the north lies Burkina Faso, Cote D'Ivoire to the west and Togo to the east. Ghana has a total stretch of 92,100square miles (238,539sq km), about the same size of Great Britain. (Patricia Levy 2002).

About 21.10% of the total land of Ghana is arable (World Bank, 2011). The country is divided into 10 regions and 212 districts (Ghana Statistical Service, 2015).

The average life expectancy of Ghana according to United Nations Development Programme (UNDP) is 64.6years. English is the official language (UNDP, 2013).

Per the 2014 National Census, 51.9 percent the population live in urban areas with a rate of urbanization of 3.5 percent per annum. Dependency ratio stands at 71.6percent (Ghana Statistical Service, 2014). About 70 percent of the population lives in the southern part of the country. Ghana exports a lot of natural resources such as gold, diamond, manganese, bauxite, timber and cocoa as well as oil which was recently discovered.

The forest area of Ghana is estimated at 9.17 million ha accounting for about 40% of the total national land (Ghana Statistical Service, 2015).

Figure 1: Map of Ghana

Source: http://www.worldatlas.com/webimage/countrys/africa/gh.htm

1.3.2 Politics and economy of Ghana

Ghana has a significant political record as the first country within the sub-region to gain independence. The country saw a swift movement from dictatorship to democratic rule. This can be traced from 6th March 1957 when Ghana gained independence through the toil and sweat of people notably the 'Big Six' which marked the beginning of the first

republic. The fourth republic started when Ghana drafted its constitution to embrace democracy in 1992.

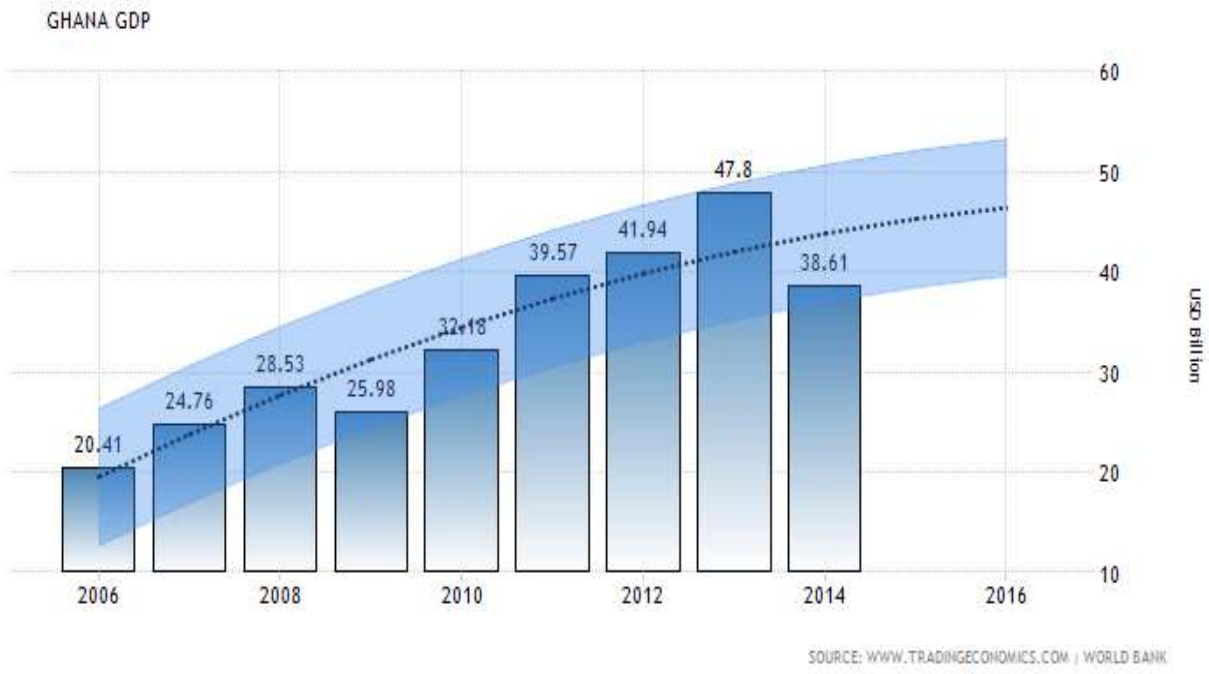
Between 1992 and 2012, Ghana experienced five successful multi-party democratic elections. A glance of the political dispensation of Ghana post independence shows that, Ghana became a republic in1960 under one party state ruled by the National Convention Party (CPP). As stated, there were series of military overthrow until Ghana embraced democracy in 1992. In 1992, the National Democratic Convention (NDC) party lead by formal president Jerry John Rawlings took the baton and ruled the country for two terms with four year duration in each term. In 2000, elections were held and the New Patriotic Party (NPP) under the leadership of John Agyekum Kuffour took over power in 2001 to 2008. In 2009, John Evans Attah Mills became the president after the tenure of office of John Agyekum Kuffour. In 2012, John Dramani Mahama was sworn in after the demise of John Evans Attah Mills. However, in 2013, John Dramani Mahama was sworn in after winning the 2012 general election.

Ghana has tried numerous reforms and approaches to achieving acceptable growth and development in its economy. According to Aryeetey et al (2000), it began with a push for rapid industrialization in the 1960s' using a variety of control measures and state interventions. This lead to the launch of comprehensive reform programme on the basis of liberalized policy regime (Aryeetey et al).

From 1983 to 1991, there were reforms to bring about stabilization. Some of the features of the reform were Economic Recovery reform in Ghana which was launched by the PNDC or Provisional National Defense Council in 1983. Between 1992 and 1996, a variable reform came into being after the economy was made to go astray after elections.

The gross domestic product (GDP) of Ghana as shown in Figure: 2 below. The data presented is based on past historical information on data modified coefficient of the econometric model and projected into the future.

Figure 2: Ghana's GDP growth trend



The rate of unemployment in Ghana is measured by the number of individuals actively seeking for employment as a percentage of the total labour force. The rate of unemployment is projected using actual values, historical information, forecast, chart and statistics in Figure: 3 below. The data used in this graph was last updated in March of 2016.

Figure 3: Projection of Ghana's unemployment rate

A general overview of key indicators of Ghanaian economy is illustrated in table 1 below. It is often the case that Ghana is ranked rather low at 140th position, with respect to human development index, which takes into account factors like life expectancy, education and income.

Table 1: Human development indicators Ghana

INDEX	VALUE
Human Development Index	0.579
Human Development index Rank	140
Life expectancy at birth	61.4
Expected years of schooling(years)	11.5
Gross National Income (GNI) per capita	3,852
Inequality-adjusted HDI	0.387
Gender Development index	0.885
Multidimensional Poverty Index	0.144
Employment population ratio	66.2
Export and import(%of GDP)	89.4
Mobil phone subscription (per 100 people)	114.8
Carbon dioxide emission per capita(tonnes)	0.4
Population, total(millions)	26.4

Source: (UNDP, 2015)

1.3.3 Eastern region and Kwaebibirem District

The region has a stretch of approximately 19,322 sq km. This forms about 8.1% of the country's land mark in totality. Eastern region ranks number six (6) in terms of land area among the ten (10) regions in the country. It is the third highest region in the country in terms of population after the Greater Accra and Ashanti region. Females form 50.8 and the remaining 49.2 are males' population percentage in the region. In Ghana, the Eastern region has 17 administrative districts and with four major ethnic groups which are the Akans, Ewe, Guans and the Ga-Dangme with the Akans dominating of about 52 percent.

The Kwaebibirem district shares boundary with seven (7) districts/municipalities namely; Birim North district, Atiwa, East Akim Municipal, Suhum Kraboa Coaltar

District, West Akim Municipal and the Birim South District at the West, North East, East, South East, South, South and South-west respectively.

The capital town of the district is Kade with a population of 16,542 people (2013 Census). "Kwaebibirem", when loosely translated from the Akyem language is "Virgin forest", which connotes its evergreen vegetation. Various species of timber, such as mahogany, emire, odum and wawa can be found in abundance in the district's wide expanse of forests. The economy of the District is predominantly agrarian with both subsistence and commercial production of food and cash crops. Oil palm, cocoa and citrus is the major traditional cash crops cultivated. (District Analysis report, 2014; Ghana Statistical Service, 2013).

However, the introduction of illegal mining along the main river (River Birim) has drastically declined the forest ecosystem.

Figure 4: Map of Eastern Region showing Kwaebibirem District

Source: Kwaebibrem District Assembly, 2013.

II. Literature review

2.1. Introduction

One of the primary criteria used to characterize illegal mining is the absence of land rights, mining permit, and manipulation or over exploration without the necessary legal right that authenticate their activities. According to 'The Report' :(Ghana 2011), the activities of illegal mining are of two types namely, unpermitted exploitation outside the zone controlled by mining companies and those outside the major mining zone area.

According to Akabzaa and Darimani (2001), the mining sector is a significant component of the national economy and has played an important function in Ghanaian economy. This has prompted a trade-off of safety regulations and posing severe hazards on forest ecosystems and water bodies (Boateng, 2015).

2.2. Features and definition of mining

Mining may be defined as the excavation of the earth crust for minerals; economic or non-economic minerals. Mining covers the mining of precious and industrial minerals, quarrying, gravel and sand winning. As stipulated in the Ghana Mining Laws and Regulation booklet Vol.1, Ghana's definition of mining encompasses the pulling out of "any substance in solid or liquid form, occurring naturally in or on the earth, or on or under the seabed, formed by or subject to geological process including building and industrial minerals but does not include petroleum or water"; Ghana's Minerals and Mining Law, PNDCL 84 (Aryee, 2001).

2.3. Illegal mining

Illegal mining can best be described as any form of mineral extraction without legal title to the prospect being worked where required by the authorities. The major target of illegal miners are high unit value minerals offering a prospect of high returns, such as diamonds, coloured gemstones, gold, and, to a much lesser extent, relatively low value minerals. An added advantage of high unit value minerals is that their transportation does not require an elaborate infrastructure. Thus, many illegal mining operations are found in locations lacking basic infrastructure (Cramer, 1990).

2.4. Brief insight of mining in Ghana

Ghana has a long mining history dating back over 1000 years (Annin, 1992; Government of Ghana, 1980; and Sweeting and Clark, 2000). The country is well blessed with important mineral resources, notably diamonds, gold, manganese, and bauxite. The highest contributor to the economy from the point of view of mineral resources is gold. It contributes almost 38% of the total mineral resources in the country and 95% of exports from minerals (Aryee, 2001) as well as about 80% of all mineral revenue (Adadey, 1997).

Ghana as it stands now has two sorts of gold mines: small-scale and large-scale. Small-scale miners are fundamentally or independently employed indigenous youth, with minimal budgetary allocation and constrained mining expertise. While illegal, this activity dominates the small-scale gold sector, with an estimated 60,000 people involved in *galamsey* (Aubynn, 1997).

2.5. Causes of illegal mining

According to Hilson (2006), illegal mining is mainly caused by the following factors; inaccessibility to mineral rights, poor institutional framework and ineffective security measures at mine sites. There are many factors contributing to the absence of mineral rights entitlement. Paramount among the reasons is the exorbitant controlling of mining operations by that State. The preceding era to the economic liberation that saw the proliferation of most third-world countries over the last ten years, the socialist idea of economy was adopted by most developing countries; this in effect affected and had a major influence on policy types in their economies.

Third-world countries usually adopt this strategy in declaring authority over natural resources with the ultimate aim to immensely boost foreign exchange earnings as well as revenues by exploiting the available mineral resources. More also, complete monopoly of the sector by the State means the restriction of small scale miners from mining, which is the major contributing factor pushing artisanal mining groups to indulge in illegal mining activities which could have easily been prevented or controlled. As a consequence of government autonomous control of these mining sites, ensuring security in these sites is quite difficult to manage across the country when such an activity erupts. Laying ones hand on mineral rights will as well be difficult and often bureaucratic, structures to attain licenses for the exploration of minerals (Kambey et al., 2001).

Artisanal mining is more often than not characterised by the utilisation of basic tools which are easy to move around. Illegal mining is one of the open secrets characterised by this sector of mining in the industry. Notwithstanding its controversies, small scale mining is not always illegal; it involves legal and illegal, as well as structured and unstructured activities. There is usually a basic form of administrative structure which includes hired labour force. Machinery involved in this sector is usually basic and primitive. The trade in gold and gemstones is highly attributed to this sector of the industry. On the other hand, there is the licensed group of small scale miners; this sector shows improved and modern systems of administration as well as the use of advanced sophisticated machinery in their operations. Although for the most part, there is no illegal mining activity in this particular sector, as in the case of the other sectors, illegal trading of gold and gemstones still is an eminent fact associated with this group. Reasons accounting for this anomaly may include; evasion of tax, marketing difficulties and pre-financing of operations by illegal buyers considering the high operational cost involved (Hilson, 2003).

Figure 5: Illegal miners arrested in Ghana

Source: TVC News

2.6. Impacts of illegal mining

There are serious economic, social and environmental consequences associated with illegal mining activities. The illegal nature of the sector makes it practically difficult for operators in the industry to observe the necessary safety, environmental and health regulations involved (Hilson, 2001).

According to Hilson (2006) there are four noteworthy demerits of illegal mining. These are recognized as:

- Uncontrolled environmental degradation;

- Poor health and safety;
- Lawlessness, particularly crime, in highly populated gold mining communities and;
- Loss of tax revenues from the activities by the government.

When it comes to issues of environmental degradation usually, small-scale miners are the worst criticised. Managing this sector is relatively difficult considering the huge number of people involved and the proximity of their activities. Illegal miners more also make the situation further complicated since comparatively they are difficult to manage (Manji, 2009).

Figure 6: Destruction to property

Source: mordenghana.com

Above are a school structure and a roof of a house ripped off by recent storm at Adankrono a village within the research area due to the excessive cutting down of trees for mining related activities.

2.7. Demand for gold

There are four broad categories of gold demand as presented by World Gold Council 2015. They are technology, investment, jewellery and the Central banks and other institutions. According to the gold demand trend from the World Gold demand trend 2015, Jewellery make up the highest proportion of gold use of about (52.7%). Investment accounts for 12% and approximately 26.9% for technology. The Central Bank and other institutions account for almost 12%. The year 2015 showed 6% decline in the prices of gold in the world market. India and China are reported to be the two most significant countries leading the world's demand for gold for the last 5 years. Per

the report, the demand of gold by India is mostly driven by jewellery as the demand for jewellery reached its third highest record in the year 2015. China's is more equally driven by the above mentioned three categories (Ousman, et al., 2012).

2.8. Socio-economic significance of mining

Despite the fact that illegal, hazardous mining is unfriendly to the country's development, *galamsey* serves as a source of income and job for these mining groups and their more than ten thousand inhabitants. The small-scale mining of these valuable minerals has had huge financial effect on numerous people and communities as it provides a source of employment for the general population and it is the main or only source of income available to the people. Among rural communities where mining is predominantly common, the activity has reduced rural-urban drift, promoted local economic development and contributed towards poverty reduction. What's more, the mining operations are valuable in essential skill development and add to the change of unskilled labour into semi-skilled and skilled workers (Teschner, 2012).

More significantly, because of the low barriers to entry with regards to the need for formal education and capital requirements, small-scale mining operations offer superb platforms for the development of local entrepreneurs. In rural communities where different occupations are low paying or non-existent, small-scale mining appears as a profitable source of employment. The mining sector additionally provides raw materials for local industries for their operations (Amankwah & Anim-Sackey, 2004).

2.9. Employment

Mining has been noted as a source of employment to the various rural populations who have few alternatives in terms of jobs. Undoubtedly, most of the 'white colour' jobs are non-existing in these rural areas. Ofosu-Mensah et al. (2011) contended that owing to the fact that "jobs are concentrated in the large cities people in the hinterlands look to small scale illegal mining or *galamsey* as a gainful sector regardless of how loathing it may be".

Notwithstanding the fact that no exact artisanal small-scale miners' employment figures can be found for Ghana, labour force for small-scale miners are mere estimates due to their migratory nature. For as far back as 5 years the assessments for artisanal small-scale miners has been 1 million, whilst from 2005 to 2010, labour force was projected at 500,000, for ASM only (majority are illegal '*galamsey*') as against the estimated

number of 28,000 labour force employed by large scale mining (Ghana mineral commission, 2014). According to the Ghana Chamber of Mines report (2013), about 60% of the country's mining labour force is employed at the small scale mines. This labour force also incorporates women who play a critical part in reducing poverty and hunger in Ghana (Ofosu-Mensah, 2011).

2.10. Mining and water pollution

Mining can contaminate surface and groundwater supplies. Groundwater withdrawals could be a treat to streamside environment and ecosystem several miles from the particular mine site. Mining activities and operations use water for mineral extraction, reducing dust particles and meeting the demands of miners on site. The quantity of water needed by a mine may vary according to its size, the mineral being extracted, and also the extraction method used. For example, metal mines that use chemical processing method to concentrate forms of metals like copper and gold use considerably more water than non-metal mines like coal and salt mines (Water Quality in Mining – MiningFacts.org, 2016).

Water pollution resulting from mining activities is commonly cited as a significant concern among stakeholders. In previous years, mines operated with no proper environmental management strategy and supporting technologies that exist among larger mining corporations nowadays. Effective monitoring of environmental violations and imposing the principles that combat those violations has been tough as a result of an absence of resources and also the wide scattered and inaccessible nature of ASM (Tutu, 2012).

In recent years, most of the Environmental Impact Assessments (EIA) related to biodiversity loss, environmental contamination, creating of sinkholes and the like, as in the case of mine sites exposed to semi-arid climates (Razo et al., 2004).

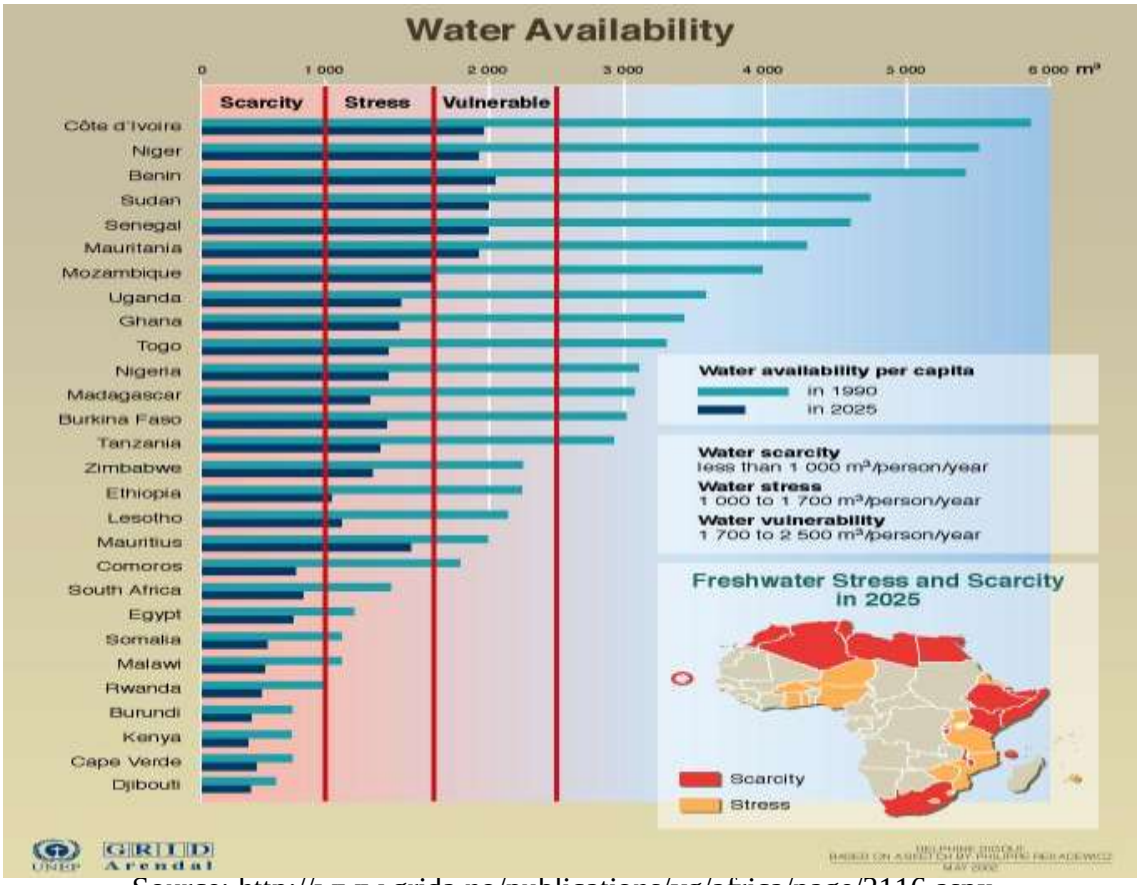
2.11. Availability of water in Africa

Water availability in most part of sub-Saharan Africa is not fixed in various countries. It is an undeniable fact that only wet areas have records of abundant water supply. These areas include West and Central Africa .As Sharma et al. (1996) indicated, inadequacy of water is evident in 8 countries in Africa during 1990 with the situation expected to deteriorate further due to rapid expansion in population, urbanization, and boom in economic development. It is anticipated that in the near future approximately

300 million people in Africa will live in areas with low water supply. More also, the world bank projects that in 2025, around 18 countries in Africa will encounter acute water supply that will affect about 600 million inhabitants (Sharma et al., 1996).

One debilitating challenge in Africa is the accessibility of inhabitants' both in cities and villages to adequate uncontaminated water. Accessibility to uncontaminated water and hygiene at the slums in Africa is more pathetic than before as shown by various records. In 2004, World Health Organisation published that less than 20% of the populace in Sub-Saharan Africa have access to portable water within their vicinity (World Health Organization, 2008).

Figure 7: Availability of water supply in Africa



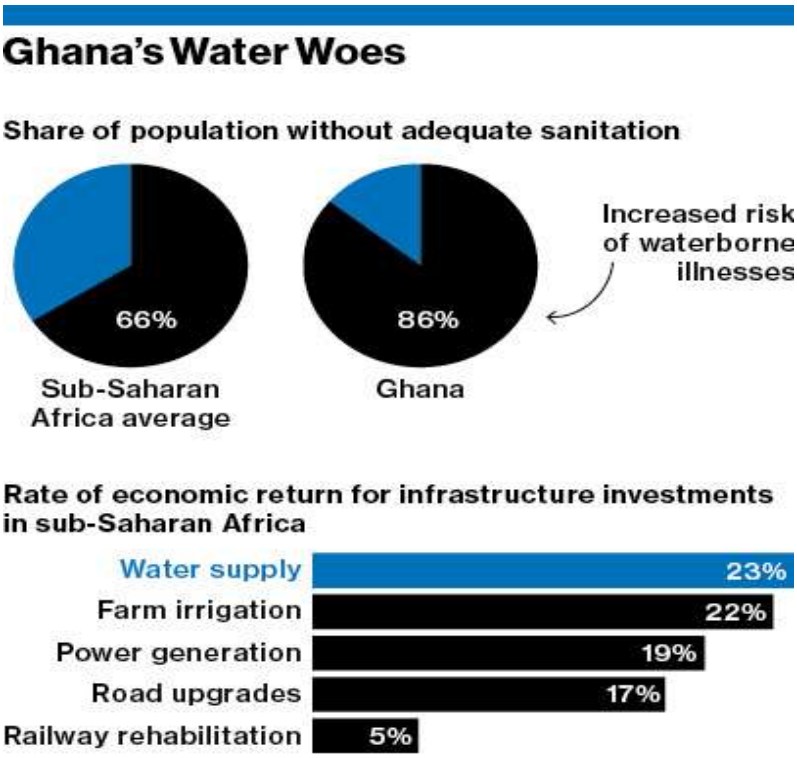
Source: http://www.grida.no/publications/vg/africa/page/3116.aspx

2.11.1. Overview of water situation in Ghana

Ghana's $35 billion economy, whose projected growth of eight percent in 2016 would outstrip the sub-Saharan African average for a sixth straight year, cannot continue at this rate without the establishment of a contemporary water network. With more than half of the rural populace dependent on unsafe water sources, water-related diseases are

common in Ghana, especially in the rural areas where poverty is prevalent. Ghana faces serious difficulties in meeting the challenge of providing enough clean and safe water for all rural and urban dwellers. As far as the early 1990s, Ghana's water and sanitation sector has seen major reforms to deal with weaknesses. However, Illegal mining activities has been a major hindrance especially in rural areas in their efforts to attain clean and safe water for drinking and domestic activities (Danso et al., 2006).

Figure 8: Percentage of population without water supply



Source: UN Aquastat, World Bank

2.11.2. Water pollution type mining from activities

Basically, there are four main forms of the impact of mining the quality of water.

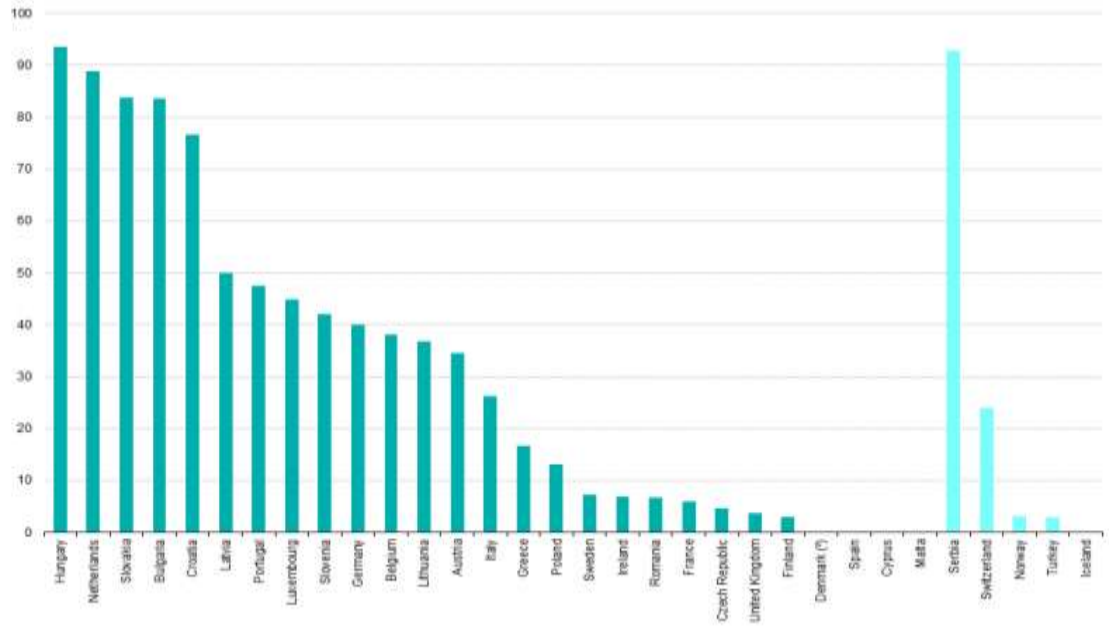
1. Heavy Metal Contamination & Leaching
2. Acid Mine Drainage
3. Erosion and Sedimentation
4. Processing Chemicals Pollution (De Marsily, 1986).

2.12. Water availability in EU

Over four decades ago, Europe has experienced the continual depletion of water resource. Over the period, there has been an increase in human use of water, with little or no consideration of a resource initially taught as self-purifying. As far back as 1960, there were significant observations on the consequences of anthropocentric water use. These were possible due to the advancement of science. In recent times, scientific knowledge in environmental field enjoins the concept of ecosystems (Delort & Walter 2001).

For considerable time, there has been an increase in the demand for cleaner groundwater, river and lakes and coastal beaches by citizens. The following has recently been confirmed by an opinion poll (Eurobarometer) in about 25 European Union Countries; respondents were asked to list five major environmental issues that they were worried about, averaging the results obtained from the 25 European Union countries used in the research, 47% were worried about 'water pollution', regarding figure of individual countries, the number went up as far as 71% in some countries. The European Commission's commitment to make water protection one of its priorities is as a result of the demand by citizens. Principal to the new European Water Policy is the fact that polluted waters will be cleaned and clean waters will be maintained. The roles of citizens and groups are vital in order to achieve this aim; this explains the need to get citizens involved in the new European water Policy. The European Water Policy has been through a careful restructuring process, and this led to the operationalisation of the new Water Framework Directive (WFD) in 2000, which has future protection of water as its objective (New EU Water Framework Directive - Environment - European Commission, 2016).

Figure 9: Share of external inflow from neighbouring territories in renewable freshwater resources



Source: Eurostat, 2016

A new dimension strongly described and instrumented the ecological vision which was adopted in the Water Framework Directive (WFD) and blames human activities as a cause of disturbance inhibiting water bodies from attaining their desired reference status. To this end, the WFD suggest humans take up their roles toward water ecosystems by decreasing their impact on these aquatic ecosystems in order to achieve the desired pristine nature. The new water directive developed under this ideology is not cause-related but rather proposes a more in-depth approach to water management and considers surface running water as a "life milieu". Regarding the fact that water bodies are 'containers' of physical and chemical elements, surface water on the other hand also contributes to biological aquatic ecosystems. This affects the activities of organisms living on land and both quantitatively and qualitatively surface water is influenced by groundwater. This adjustment considerably raises the level of complexity covered by addressing various ecological interdependencies for example between the quantity and quality of water and between aquatic and terrestrial ecosystems (Steyaert & Ollivier, 2007).

The intense inadequacy of water resources of "good" quality emerges as a vital environmental drawback on a global level (Callopin & Rijsberman, 2000). The situation

in the EU has been duly normalised with appreciable water quantity supply to almost all parts; increasing satisfaction of residents and enhancing cultivation purposes as well.

2.13. Mining in Europe

There are series of publications related to water pollination as a result of mining accidents and related activities which has necessitated the re-evaluation of environmental policies relating to mining in Europe and other countries. Considering the fact that ground and surface water protection from mostly industrial pollution has been an issue of legislative protection in the past, water pollution associated with mine operations has less coherently been regulated in this regard. Pollution from mine waters is significantly different from other forms of industrial pollution, especially its ability to exist at high levels and also continue for a lengthy period even after the end of production process (Younger, 1997).

Figure 10: Waste generation by economic activity and households, 2012

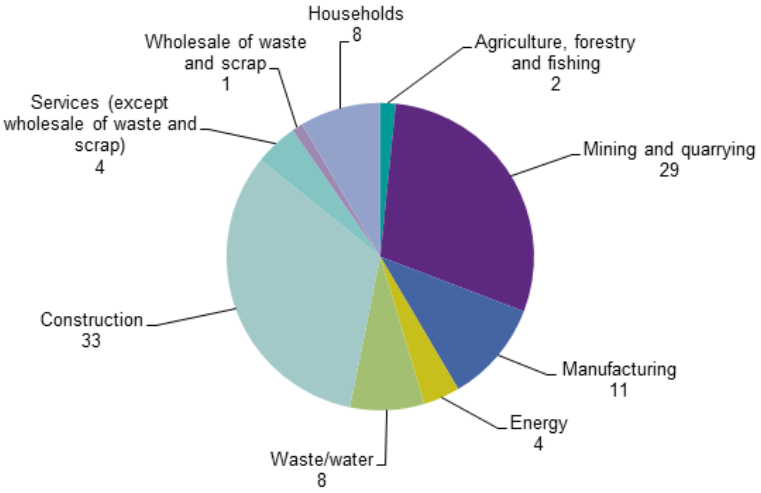
	Total	Mining and quarrying	Manufacturing	Energy	Construction	Other economic activities	Households
EU-28	2 514 220	733 980	269 630	96 480	821 160	379 560	213 410
Belgium	67 630	115	17 736	1 314	24 570	18 891	5 004
Bulgaria	161 252	141 083	3 009	9 533	1 033	3 841	2 755
Czech Republic	23 171	167	4 376	1 063	8 593	5 739	3 233
Denmark	16 332	18	1 610	893	3 867	6 216	3 727
Germany	368 022	8 625	56 596	8 050	197 528	60 752	36 472
Estonia	21 992	9 355	4 121	6 258	657	1 165	436
Ireland	13 421	2 025	4 599	396	366	4 379	1 657
Greece	72 328	47 832	4 183	12 259	813	2 383	4 859
Spain	118 562	22 509	14 594	5 772	26 129	28 333	21 224
France	344 732	2 477	21 431	2 100	246 702	42 024	29 996
Croatia	3 379	5	425	108	682	968	1 191
Italy	162 765	720	34 142	3 616	52 966	41 708	29 613
Cyprus	2 086	218	98	2	965	353	451
Latvia	2 310	2	396	133	8	558	1 213
Lithuania	5 679	26	2 551	29	419	1 477	1 177
Luxembourg	8 397	131	509	2	7 079	426	249
Hungary	16 310	91	2 991	2 672	4 038	3 638	2 681
Malta	1 452	45	9	2	1 041	201	155
Netherlands	123 613	179	14 115	1 342	81 354	17 758	8 864
Austria	34 047	51	3 636	622	19 471	6 247	4 020
Poland	163 378	68 035	31 135	20 706	15 368	18 809	9 324
Portugal	14 184	243	3 188	422	928	4 672	4 731
Romania	266 976	223 293	6 029	9 043	1 325	22 638	4 647
Slovenia	4 547	14	1 345	1 069	535	941	641
Slovakia	8 425	311	2 516	1 046	806	2 090	1 657
Finland	91 824	52 880	14 531	1 011	16 034	5 635	1 734
Sweden	156 307	129 481	6 158	1 852	7 656	6 967	4 193
United Kingdom	241 101	24 044	13 596	4 965	100 230	70 759	27 506
Iceland	529	0	93	2	11	191	233
Liechtenstein	467	29	12	0	107	2	316
Norway	10 721	470	2 639	89	1 881	3 205	2 438
Montenegro	386	1	33	351	0	0	0
FYR of Macedonia	8 472	802	1 304	6	0	6 360	0
Serbia	55 003	47 896	760	5 744	364	238	0
Turkey	1 013 226	950 587	13 141	18 424	0	289	30 785
Bosnia and Herzegovina	4 457	72	1 213	3 171	0	0	0
Kosovo	1 167	177	80	151	0	268	490

Source: Eurostat, 2016

There are significant evidence of accidental pollution problems that are as a result of leakages and spillages from mining activities and this effect stretches beyond reach. The effects can be seen in member countries like United Kingdom, Italy, Sweden and Poland. In the 1998 report on the 'Environmental Assessment of Mining Project' report

by the World Bank, the dangers and potentials of metal mining were clearly listed. These dangers were in relation to both human and environmental effects and ways in which mining tailings could be managed since it is the most crucial environmental threat in mining. Aquatic systems including streams and rivers are the most vulnerable to pollution resulting from mining operations. This is because water is a necessity in mining operations because it has a significant effect on the operations as well was discharging of waste. These tailings from mining operations into water bodies pose severe havoc to both plants and animal species including man. Bio-accumulative and persistence are the characteristics of heavy metals which in effect are highly toxic and therefore have long term damaging effects on the ecosystem. The European Union's Treaty, mandate the members states to ensure environmental protection to be integrated in all policy implementations to achieve sustainable development. Though the EU has enormous competence in managing waste form mines, implementation on the part of Member States have great variations (Sol et al., 1999).

Figure 11: Waste generation by economic activity and households, EU-28, 2012 (%)



Source: Eurostat, 2016

Ensuring regulation of the mine waste facilities alone without the mine undermines the main source of the pollutant. Taking the full cycle of a mine process into account, it could be realised that the after closure phase is temporarily severe in terms of pollution but practically regulation in this phase is poor (Kroll et al., 2002). To be able to drastically reduce the immense pollution posed by mines, careful regulation is significant especially after the post-operation phase where pollution is greatest.

III. Methodology

3.1. Introduction

This research project was mainly a case study design. However in this particular segment, there is a brief overview of the qualitative and quantitative research and also the mixed method approach. Next is the section that deals with the reasons for preferring the mixed method approach to other methods of research as well as potential cautions associated with this method. Lastly, the section will present the study's research design, sampling methods, data analysis as well as challenges and ethical evaluations.

3.2. Study area

The Kwaebibirem District was first created in November 1988 by Legislative Instrument (L.I) 1425, however in 2012; Denkyembour District was carved out of Kwaebibirem District, which has re-established it as a new District in June 2012 under the Legislative Instrument 2043. Kade is the capital of the district (Ghana Statistical Service, 2014).

The current population is projected at 122,816. Over two thirds of these live in rural areas. Crop farming is the predominant economic activity and thus serves as the source of livelihood for over 72% of the population and contributes about 80% of the internally generated funds (IGF) of the district. The main development problems facing the district include low agricultural output resulting from illegal mining activities, the use of rudimentary farming methods, poor road network and inadequate supply of basic social services such as education, health, water and sanitation (Kwaebirem District, 2014).

Figure 12: Map of Kwaebibrem

Source: Ghana Statistical Service, GIS

3.2.1 Climate

Kwaebibirem lies in the tropical zone and experiences double maxima rainfall regimes with two distinct dry and wet seasons. Temperature ranges between a minimum of 25 degree Celsius and a maximum of 30 degree Celsius, average temperature is usually from 26.5 to 27 degree Celsius (Kwaebirem District, 2014).

3.2.2 Vegetation

The District has Semi-Deciduous forest vegetation which consists of three-layer plants with dense undergrowth. The vegetation has different species of trees, herbs, scrubs and weeds. However, human activities such as agriculture, fetching of fire wood, mining and the like have undermined the originality of the forest in the area. (Kwaebirem District, 2014).

3.2.3 Literacy and education

Education is an important aspect of societal development. It is the process of acquiring knowledge, skills, values and attitudes to fully develop individual capacities for societal well-being (United Nations Development Programme, 2011).

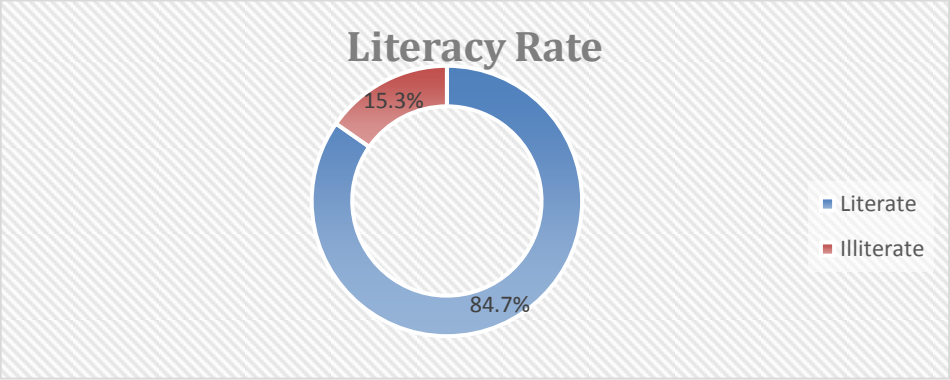
In the census held in Ghana in 2010, literacy was defined as the 'ability to read and write a simple statement with understanding'. If a person can only read but cannot write

or can write but cannot read, he or she is not literate. Similarly, if a person was literate some time ago but cannot read and write with understanding at present then he or she is not literate (Ghana Statistical Service, 2014).

In the Kwaebibirem District, out of a population of 80,064 aged 11 years and older, 84.7 percent are literate whiles 15.3 percent are not literate. From the total literate population (67813), 68.6 percent are persons literate in English and Ghanaian language, followed by those who are literate in Ghanaian language only 17.3 percent and English only 13.3 percent.

Among the age groups the population literate in English and Ghanaian languages are above sixty percent. 51.2 percent and 48.8 percent represent male and female literacy respectively. However, the proportion of illiterate females (69.2%) is more than twice that of males (30.8%) (Kwaebirem District, 2012).

Figure 13: Literacy distribution



Source: Kwaebirem District, 2014

3.2.4 Economic activities

Economic characteristics describe the conditions in a particular area. This basic fact means that the level of employment, the quality of jobs, and the access which individuals have to decent earnings opportunities is a crucial determinant of development. It is important to point out here that the information on economic characteristics reflects the economic activity status, occupation, industry, employment status and sector in the East Akim municipality. The question on economic activity was asked of all persons five years and above who engaged in any activity for pay (cash or kind) or financial benefit for a minimum of one hour during the week. A person is considered to be working if he/she receives financial benefit or economic gain for a

minimum of an hour during the stipulated time frame or was not actively engaged during the period but has a work which he can attend for financial gain or unemployed (seeking a job for the first time or was actively involved in a job earlier and is readily available in case of a new job offer). (Ghana Statistical Service, 2014).

3.2.5 Relief drainage

The land layout is often undulating and rises about 240 metres to 300 above sea level with the highest point being the Atiwa ranges rising over 350 metres above sea level. The underlying rocks are of the Birimian rock which occupies more than halve of area under consideration. This rock group contains several mineral deposits including gold, diamond, bauxite and kaolin (Ansa-Asare & Asante, 2008).

Some important rivers which drain through the municipality include the Birim, Densu and Bempong most of which have their catchment areas within the Atiwa and Apedwa Forest Ranges. Several other seasonal streams are found in the municipality. The flow of the stream is said to be from the top of the mountain to the bottom in a verdurous order (Ministry of Food and Agriculture, 2009).

3.2.6 The Birim river

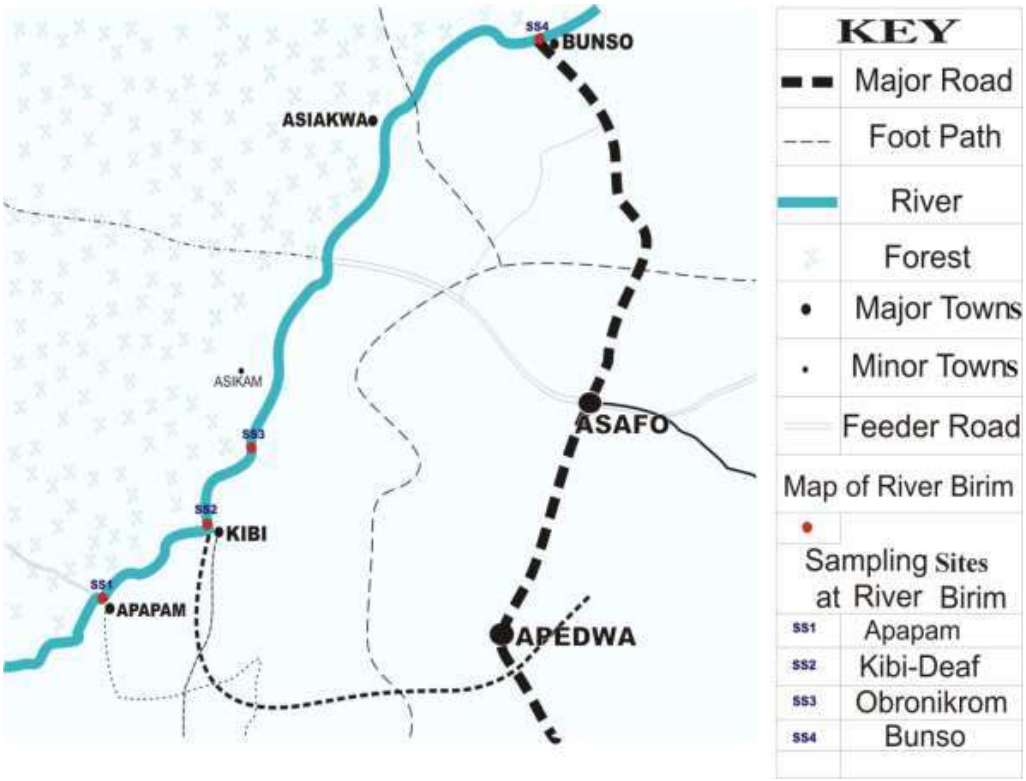
The Birim takes its source from the Atewa range of hills and follows a course of 175 km to join the Pra River. The Birim basin located between latitude $0^0 20^{'} W$, $1^0 15^{'} W$ and longitude $5^0\ 45^{'} N$, $6^0\ 35^{'} N$ has an estimated area of $3875\ km^2$ with seven important tributaries which are Apeam, Kadewa, Si, Adim, Merempong, Supong and Osenase rivers. There are trees sheltering the river along its course due to the high vegetation in the area. It is within the high rainforest zone of with high amount of rainfall of around 1650mm per annum (Tuffour-Darko & Ayibotele, 1979). Rainfall pattern comes in two rainy seasons with main and minor season at May/June and October respectively.

There is high relative humidity of between 60% and 95% within the year. February to April is the hottest season with temperature of 32°C and 22°C during cooler season from June to September and sometimes October (Ankoma, 1986).

The river Birim (from Kade downstream) and some of its tributaries, e.g., Asubone, Supong, Ablasika and Adenkensu are all diamondiferous. Diamond is the major extracted mineral in the basin however, gold is also won. Mining is both alluvial and

terracing. The bed of the streams consists of sand, gravels, rocks and generally muddy with decaying vegetable matter (Ansa-Asare & Asante, 2000).

Figure 14: Map of river Birim showing the sampling sites



Source: Asamoah, 2012.

3.3. Challenges of mixed research synthesis

The primary challenge to conducting mixed research synthesis studies is how to manage the qualitative/ quantitative divide that defines the "mix". The qualitative/ quantitative binary is a familiar way to categorise research in the behavioural, social and health sciences and it is useful as a shorthand communication of research practices. Yet this binary is also an obstacle to communication and methodological advancement as it reifies false distinctions; for example, between words and numbers, constructive and positivist inquiry and subjectivity and objectivity (Allwood, 2011; Sandelowski, Voils & Knafl, 2009; Vogt, 2008).

3.4. Data collection methods

Data collection for the study covered a period of three months that initially began from September 2015 to November 2015. The first month was basically concerned with gathering documents from the study area particularly from the Communication Officials from the Municipal Assembly and also familiarising with the boundaries and access routes of the study area. The rest of the months were primarily used for the actual field work in the study area.

Throughout the study, a combination of various data collection methods was employed in the collection of the field data. These are discussed below:

3.5. Semi-structured interview

Interviewing is the most widely used method in qualitative research and that other qualitative methods of data collection such as ethnography and participant observation at some point involve some form of interviewing (Bryman, 2008).

For this research, semi –structured is highly suitable and has been used as such. This structure was essentially used to elicit information and data from indigenous people about how the activities of illegal mining have impacted on them socially, environmentally as well as economically. The reason for using semi structured interviews stems from the fact that it helped me to get in-depth information about the health, social and ecological impacts on the general population of the study area on a one- on- one basis.

Semi-structured interviews provide a great deal of leeway for interviewees on how to reply because of its flexibility, more information could be provided by respondents just with the asking of a question (Bryman, 2008).

3.6. Sample preparation and analysis

Purposive sampling technique was utilized to be able to meet the goal of interviewing the respondents connected to the study area and affected by the activities of illegal miners. Simple random sampling was likewise used to select respondents in order to avoid bias which gave a reasonable opportunity to each respondent within the community to be interviewed.

Moreover, the mathematical method was used to determine the sample size for the survey. A sample size of 270 of the total population of 122,816 was obtained,

withholding a confidence level of 90% and a 5% error margin. This figure was retrieved from the statistics below;

$$Sample\ Size = \frac{\frac{z^2 \times p(1-p)}{e^2}}{1+(\frac{z^2 \times p(1-p)}{e^2 N})}$$

Where Population Size = N, margin of error = e, z-score = z, e is percentage, put into decimal form (Tongco et al., 2007).

3.7.Ethical evaluation/consideration

A focal moral ramification while doing qualitative research is the issue of anonymity. Since the questionnaire involved some personal information, the issue of anonymity was further increased. In order to mitigate this as much as possible, the respondents were assured of privacy before the interviewing began and were transcribed by using code names. Some illegal mining sites were observed to confirm the level of pollution and chemicals used; this was carried out by informed consent.

Informed consent entails the readily informing of participants and informants regarding the research project and its purpose, as well as making it clear that participation is fully voluntary (Bryman, 2012).

3.8.Challenges/limitations

Choosing a study area in Africa and being in Europe was a big challenge. However this challenge was surmounted by the inclusion of a research assistant whom I consulted on a daily basis. However, due to limited time and resources in the field and there was a lot of pressure on the completion of the questionnaire administration, the quality and objectivity of the work was however not compromised.

IV. Results and discussions

4.1. Introduction

This chapter presents the empirical data and findings from the field of study as given by the group respondents and key sources. The findings are presented in connection to the research questions and objectives of the study. However, sub categories of very critical issues are likewise presented under the various research questions. Some of these categories were pre-set and were incorporated in the interview guide while some of them were created as an after-effect of the interview process and the various responses that respondents gave upon probing further.

The findings are therefore presented around the following research questions: gender of respondents, occupation, year of domicile or stay in the community, parties involved in illegal mining in the area, state of natural resources in the community and impacts on forest ecosystem. The findings start with a brief description of the socio-demographic profile of the respondents who are basically residents of the Kade Township.

4.2. Socio-demographic characteristics of respondents

It is quite often convenient to have an adequate individual data or information concerning respondents who take an interest in a particular research. Such data will give readers reasonable thought regarding the classification of individuals who were involved in the research.

For this study, individual data about respondents regarding their sex, occupation and length of stay as residents in the study area was gathered.

In all, 78 household took part in the study conducted. They were comprised of both male and female respondents. The rest of the respondents were randomly selected. Out of this aggregate number of respondents, 117 of them which represents 43.3% were females while 153 of the respondents were males representing 56.7%.

This trend was however not based on any biased assumptions relating gender equality issues; this figures were justified because most of the households in the study area were male dominated, hence they were given the chance in some cases to speak on behalf of the family.

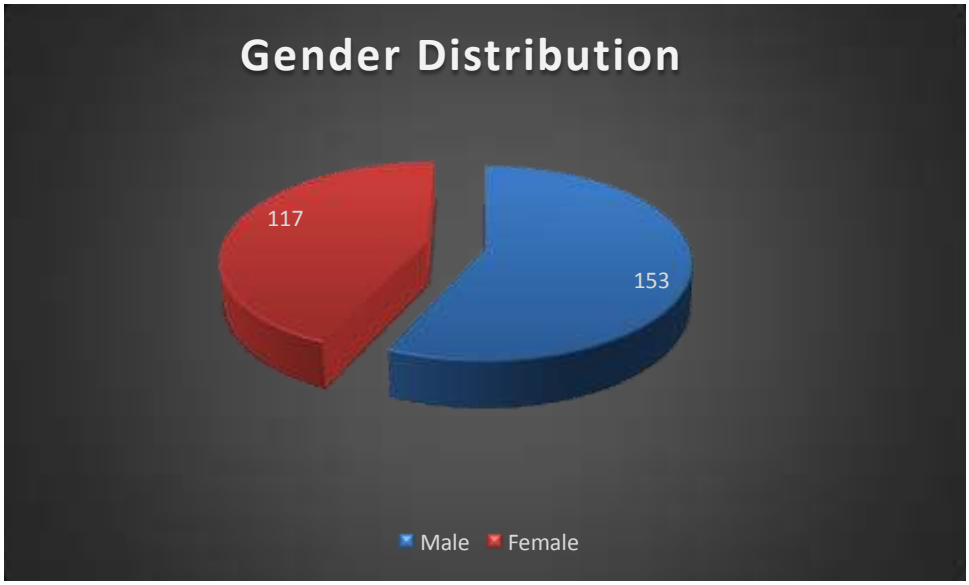
The table below depicts graphically the gender distribution of respondents in this study area.

Table 2: Summary of sample data

Male	**153**
Female	**117**
Household	**78**
Total Population	**270**

Source: Researcher, Field work

Figure 15: Gender distribution



Source: Researcher, Field work

The table shows the number of people who were interviewed for this research. Included in this number are also some officials from the Municipal Assembly, who contributed in providing vital information on the activities of illegal mining in the study area.

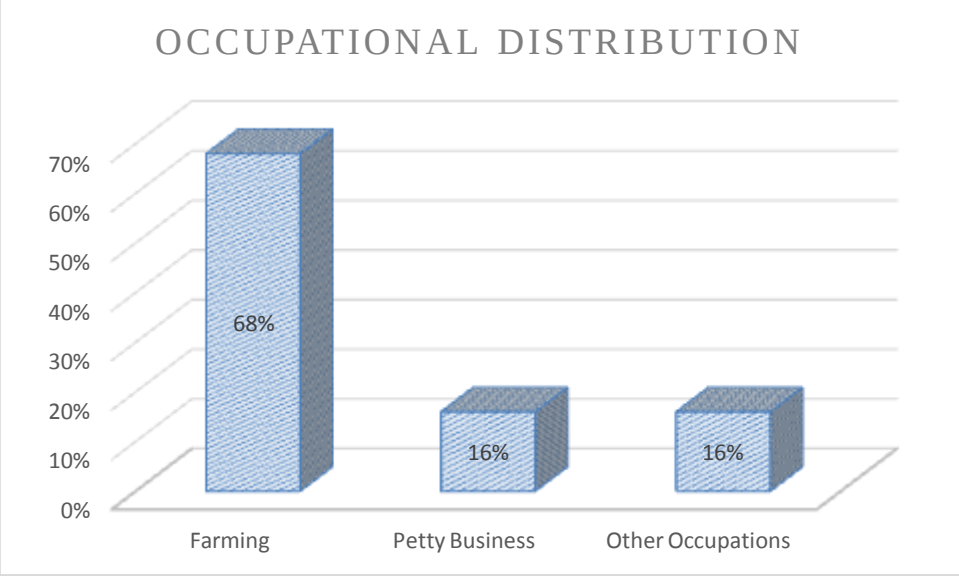
4.3. Occupational background of respondents

One major determining factor of the social status and "economic power" of people is their occupation (Wright, 1979). To understand the economic livelihood of the people as well as their poverty levels and job creation opportunities since the beginning of illegal mining in the area, there was the need to seek the occupational background of the respondents.

With regards to the responses given, significant number of the respondents was engaged in farming activities; they continue to farm even with the dangers illegal mining poses. There were also others involved in various forms of occupations, among them are teaching, petty trading as well as vocational and technical trade. It is worthy to note that although some people were engaged in petty trading, at one point or another they went back to farming when the planting season began.

Statically, 184 out of the 270 respondents (68%) indicated they were involved in farming on a full time basis (43) respondents constituting 16% also indicated in engaging in other forms of petty businesses to supplement their income from farming. The rest of the sample population were involved in other occupations either than farming; teaching, driving, trading and so on. Majority of the youth interviewed also identified themselves as farmers; this is a confirmation of the data published by the Ghana Statistical Service in 2010 which indicates the predominance of farming activities in the area.

Figure 16: Occupational distribution



Source: Researcher, Field work

4.4. Years of domicile of respondents in the community

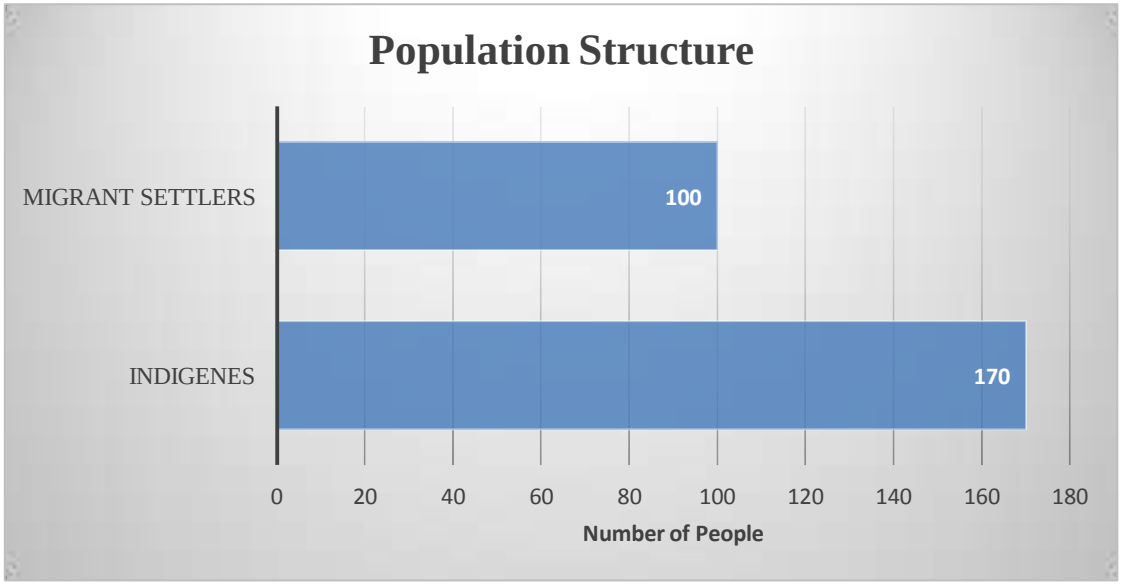
The respondents in the study area were questioned about the length of stay in the Kade community. This question was particularly necessary to ask because it sought to inquire the familiarity and knowledge of environmental and health related issues associated

with the municipality before and after the influx of illegal miners; thereby enabling respondents to give an objective comparable description of the situation.

Surprisingly, most of the people interviewed identified as indigenes of the Kade municipality; meaning they were born and grew up in this area making their judgement worthy and objective. Others even went further to explain that they haven't travelled or lived outside their community for long since all their relatives and people who mattered to them lived in the same community. As such they pledged their in-depth knowledge when it came to matters relating to the community.

A few of the respondents however were migrant settlers who have stayed in the community for over six years or more. These categories were also quite familiar with issues pertaining to the community and their contribution was also valuable.

Figure 17: Population structure



Source: Researcher, Field work

4.5. The state of natural resources in the community "now and before".

The findings on this area are from meetings made with household respondents and a key informant in the Kade community and also observations that was made on the field of study. Basically the idea was to access the current state of natural resources especially arable land, forest reserves, water bodies and even the presence of trees, flora and fauna (ecosystem) in the Kade community over the past 20 years. This was to help make a comparative assessment of the level of changes that have occurred at the onset of illegal mining in the community.

4.6. Current state of natural resources in Kade

The present situation of natural resources in the Kade community was analysed especially water bodies, landscape and trees, forest reserves, flora and fauna thus the ecosystem in totality. This information was borne by respondents who have lived in the community for longer periods ranging from ten years and over. There were a number of feedbacks delineated by the respondents for the work. The overwhelming majority however pointed out that drastic changes in the natural environment of their community especially water bodies at the onset of illegal mining in the locality has been experienced. Most of them recounted the rich vegetation and fresh water bodies that the community enjoyed before the influx of unauthorised mining activities which involved locals as well as migrants. These water bodies according to the respondents are their main source of drinking water and every household depended on it. The situation is however not the same since the activities of miners have massively polluted the water making it unsafe for drinking.

4.7.General impacts on forest ecosystem

The impacts of mining activities on forest ecosystem extend beyond the areas in which the activities are directly impacted in terms of ecological footprint. This can be divided into primary and secondary footprint. The primary footprint can be related to areas directly affected by the mining activities and secondary footprint for area around the mining zone where the direct effect is not well felt.

This section focuses on meetings with respondents, group discussions and personal field observation of environmental impacts of mining in Kade. Issues raised include destruction to primary forest and other vegetations, displacement of wildlife, erosion and flooding as well as different forms of pollutions such as pollution of water bodies, air contamination, land pollution and the pollution of the forest ecosystem in general. Personal field observations were additionally included.

4.7.1. Destruction of primary forest and other vegetation

Observations made onsite indicated that within the primary footprint mining has instantly altered forest and its composition. This effect has also spread to cover a wider area within the secondary footprint because miners cut down trees to make temporary structures where they stay and keep their items during the mining period. Surface mining activities along river Birim involve complete excavation to remove the horizon

of agricultural importance so as to pave way for parent rock materials from which soil is formed. This completely removes the various forest forms within the primary footprint therefore reducing the vegetation cover of the high primary forest. Kwaebibirem District is within the Atiwa range of forest with high forest cover. According to Reich and Frelich (2003), primary forest serves as a baseline for biodiversity at the species, ecosystem and genetic levels as well as for the preservation of cultural and spiritual values. Areas along the river in this area of study have lost this valuable quality as a result illegal mining.

4.7.2. Displacement of wildlife

Illegal mining activities within the study area have directly displaced wildlife species within the primary footprint as a result of vegetation lost. VanWilgenburg et al (2003) indicated that bird nesting habitat will be less due to loss of trees. Species of animals that require no fragmentation in territory have evacuated due to illegal mining activities. Per responses from some of the respondents, hunting business has completely collapsed as a result of mining in the community.

4.7.3. Erosion and flooding

Some of the respondents were of the view that because of the exposed pits left by miners and complete vegetation removal, soil erosion is a common phenomenon in the area of study. Mention was also made of the fact that flooding is common in the area especially during the rainy season which usually affects inhabitants downstream with the worse incident of flooding recorded in July 2011 at Kade/Adankrono.

4.7.4. Water pollution in Kade

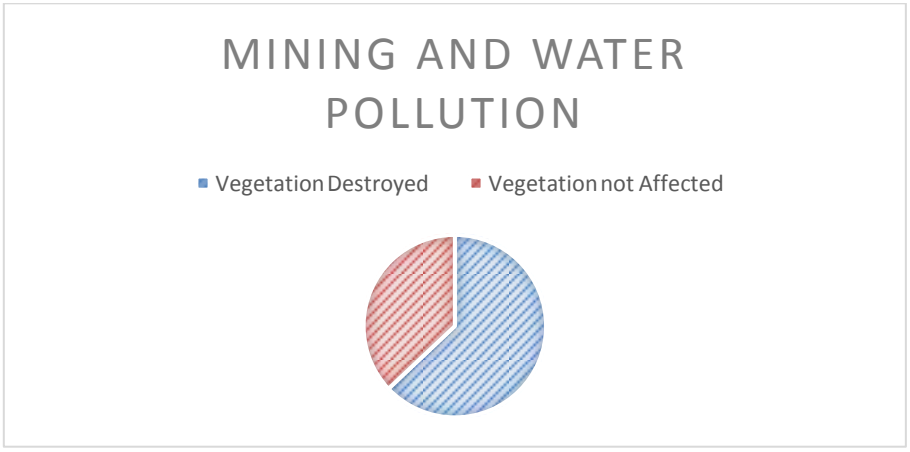
One of the three goals for better water management is poverty alleviation which is not for economic gain, along with food security and ecosystem conservation (Viala, 2008). For the general population of Kade, water is an essential asset in their lives especially in their occupation as farmers. In the locality, water bodies provide access to portable drinking water for the entire population and in addition for irrigating their crops and

farms especially during the dry seasons when there is no rainfall. It is likewise utilized for an extensive variety of family and household chores and constitutes an imperative aspect in the day to day activities of the Kade community. Considering the enormous importance of water bodies for the people of Kwaebibirem District, they were asked how their water bodies have been impacted as a result of illegal mining activities in the locality.

Majority of the respondents, thus 254 respondents representing 94% indicated that their water bodies have been polluted and as a result rendered it unusable. About 16 of the respondents constituting 6% noted that the water bodies have not necessarily been polluted but rather they are not using them again because of the warning given to the community by health experts and the community leaders so could have used it had it not been the warning.

Rainwater was also a major source of drinking water before the illegal mining activities in the area however they do not resort to rainwater anymore because of the fear that the atmosphere has also been polluted and hence rain water. The community now depend on outdoor and community pipe borne water for drinking household activities.

Figure 18: Mining and water pollution



Source: Researcher, Field work

4.7.5. Air pollution in Kade

Living organisms including man need air to survive. It is considered as a significant component for humans' life. Its pollution has a more detrimental effect to health (Wolfe, 2002). Nevertheless, good and quality air can be a challenge considering the present state of affairs in the research area. A few respondents indicated that there are

hasn't been much air pollution since the activities of these miners began. Others on the contrary indicated the use of machinery that emitted a lot of pollution unto the atmosphere; these machines were typically used by illegal Chinese miners in the area. Part of this pollution was also as a result of heavy trucks that were used to support the mining process. Plants such as cocoa, palm and cassava farms are visibly seen with dust covering their leaves due to dust produced by passing vehicles from mining activities.

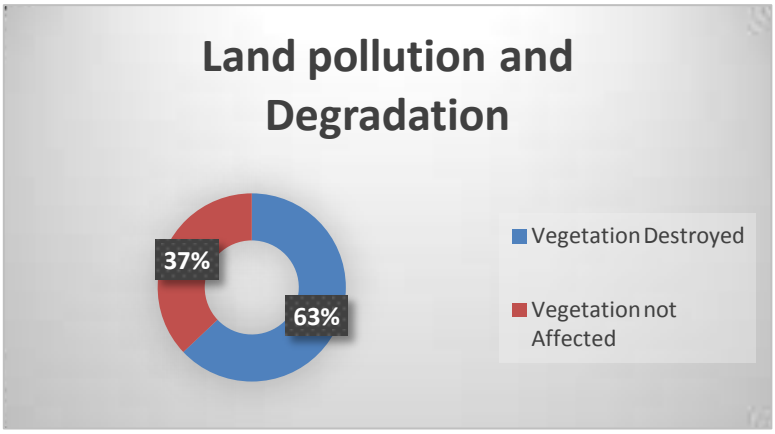
Also, another respondent noticed that presently, water stored in barrels and other containers changes colour with time and that he could noticeably see a few particles settled on the water surface in the containers.

4.7.6. Land pollution and degradation

Land is obviously a valuable asset to many people and for the people of Kwaebibrem District. This essential asset is so critical to their livelihood since it is the very source of their business particularly with the majority of them being farmers. The respondents were quizzed whether this asset has been affected in any capacity with the commencement of illegal mining in the locality and whether they feel this asset and their occupation has been undermined in any way.

Majority of the respondents (170) indicated that their land to a larger extent degraded and destroyed by illegal mining operations. About (100) respondents also noted that only a small portion of the land has been excavated so far for mining and as a result did not see how their land is seriously affected or destroyed by these miners. It was later hinted by one of the respondents that those vihemently defending illegal mining were partly involved in one way or another in the activity. Others too were of the view that since most of the illegal miners used simple and less sophisticated machinery, the open pits can be coveres easily when a session is completed. By observation, I realised huge heaps of sand abandoned in some mining sites, these piles of sand are forced to the water bodies by running water thereby polluting them.

Figure 19: Land pollution and degradation



Source: Researcher, Field work

4.7.7. Noise pollution in Kade

Noise pollution is usually not considered as a form of pollution by locals especially in rural areas such as the Kwaebibrem District. Considering the dangers of noise and its effect on humans as well as animal life, the respondents were asked whether the activities of *galamsey* contributed any form of noise. According to responses received, these artisanal miners typically do not use sophisticated machinery so there were no issues concerning noise pollution. This situation however deteriorated when the Chinese arrived; since they brought along simple portable machinery to assist them in their activities. These machines however may sometimes be noisy depending on how close one lives to these mining sites according to the respondents. There were few complaints that one could hear these machines from the desperate illegal miners even at dawn when they are trying to get some sleep. When they were asked if the miners used the dynamites in blasting rocky areas, none of the respondents could confirm this. It was then deduced that these artisanal miners do not resort to blasting the land in their activities.

The table below shows a summary of whether the effect is direct or indirect from ecological footprint point of view.

Table 3: Impact on ecological footprint from ecosystem point of view

Impact on forest ecosystem	**Primary footprint**	**Secondary footprint**
Destruction of primary forest	✓	✓
Direct habitat loss from each species	✓	○
Nesting habitat loss	✓	○

Displacement of wildlife	✓	✓
Disturbance of watershed	✓	○
Species very sensitive to aquatic chemistry	✓	✓
Erosion and flooding	✓	✓
Water, air, land and other pollutions	✓	✓

4.8. Health implications of the environmental impacts

The environmental impact activity is the difference between the situation of the proposed site for mining activity before, during and after mining (Boateng, 2015). When mining in not regulated as in the case of Kwaebibrem District, there is a risk of exposing harming substances unto the environment. The respondents were again asked about the environmental impacts and its relation to the health of the people living in the affected areas. The information the respondents gave were quite touching. According to them almost every new disease or illness in the locality was in one way or another linked to the activities of these illegal miners. Their water bodies were hugely polluted with substances of mercury since this is the main extractive chemical used in *galamsey*. There were outbreaks of malaria according to the locals since most of the pits used for mining are left uncovered after mining. These pits collect stagnant water and serves as a breeding ground for mosquitoes. There indigenes were at the mercy of illness such as cholera, diarrhoea, coughs, flu and surprisingly even cancer as reported by a respondent. This was a confirmation of the information given at the local hospital when I inquired the most reported cases of illness, however the issue of cancer could not be confirmed at the hospital.

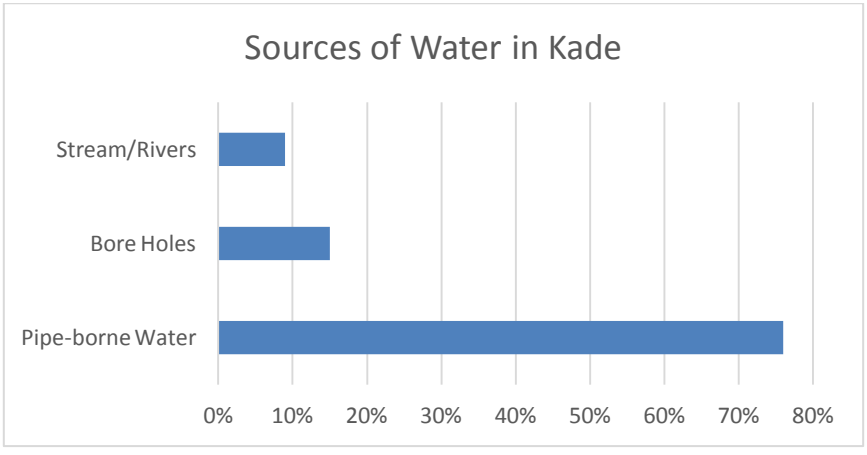
4.9.Management of the environmental impacts of mining

This section is specifically the information gathered of personal interviews with respondents on coping strategy as well as survival mechanisms adopted by the Kade community in response to the environmental impacts that exists within the community. It additionally finds out the nature of the coping mechanisms and the way these mechanisms were developed or obtained so as to regulate the impacts to the barest minimum.

4.10. Management of environmental and health impacts by Kade residents

Considering the dangers posed by these illegal mining activities it was obvious that the community had a strategy to reduce the effects. This was necessary considering farming as the main occupation of the inhabitants. Respondents were asked about some of the coping strategies employed in order to reduce the effects that came along with illegal mining. On the issue of noise pollution, the respondents made it clear they had no coping mechanism and that they are gradually getting used to the menace. Also, for impacts on water, it was clear that some measures have been taken by the locals in response to the effects. Most of the respondents indicated that water bodies in the community are no longer usable due pollution. Some respondents (76%) resorted to outdoor pipe borne water in the community for drinking and household chores. They were quick to add that the pipe borne water was expensive and further worsened their condition as they were low income earners. Deep bore holes were another source of cheap water which about (15%) identified as their main drinkable water. Others (9%) who could not afford either pipe borne water or bore holes resorted to walking long distances to areas where the streams were less affected to get water. They however had to boil the water at high temperatures in order to kill all surviving bacteria before drinking.

Figure 20: Sources of water in study area



Source: Researcher, Field work

4.11. Management of environmental and health impacts by authorities

The government as well as the local authorities have over the years expressed their disapproval of illegal mining. There have been several occasional raids and arrests by

the Forestry Commission of Ghana in several collaborated operations with the police and military. This however has not stopped the activity. There is high demand for gold over the world; these illegal miners often cash in their minerals at the black market. It is difficult for the activity to completely halt considering how lucrative it is. It is however alleged by some respondents that few traditional leaders are beneficiaries of these illegal mining activity hence find it difficult to clamp down the trade. These traditional leaders are the custodians of the land and in most cases it is believed that lands or concessions are given out under their authority.

4.12. Land reclamation

Little can be said about plans by miners on land reclamation of the site exposed to surface mining at the study area. The researcher's observation showed the a number of exposed deep pits have been left uncovered by the miners and have moved on to different sites within the same vicinity without any plan on land reclamation.

It is a well known fact that soil formation takes thousands of years. Although better than nothing, land reclamation will not restore all the soil functions as before the mining but will restore only a minimal amount of soil function. Frouz et al (2003) stated that short grasses will recover before communities of trees.

V. Conclusion

In this final chapter, there will be some short conclusions, or summary of indications and their connection to theory as far as this research is concerned. Taking after the outcome of this research, some humble recommendations were made for potential actions that could serve to enhance the circumstance of the present situation in the research area.

With the information gathered from this research, it is clear that the effects of the *galamsey* on the research area are quite complicated; some positive and some negative. The effects on the ecosystem as a result of these illegal mining activities are obvious for all to see.

It is estimated by the municipal assembly that the cost of reclamation of farmland lost to illegal mining activities will be about GHS 80m and GHS 115m. This is an alarming indication that may imply that these farmlands may never be restored, or can be long-lasting due to the high cost of reclamation.

With the prolific use of mercury in mind, the environmental impact from the *galamsey* can only be termed heart-breaking. In any case, taking a gander at the economic impact on the local communities, the total impact's character is not clear-cut. Farmers appear be the main losers, as they either offer their land for sale, or get their farmland polluted by dangerous chemicals making it infertile and thereby losing their source of income.

These unlawful local miners notwithstanding, are in most instances the financial spearheads, as they have embraced Chinese techniques and are presently acquiring significantly more minerals than previously. Aside the increased in income of some of these local illegal miners the activity has also lead to a rampant increase in other negative impacts such as; destruction of the ecosystem, land degradation, and other health implicated situations. This is in accordance with Lebel's (2003) theory, which reveals that environment, communities and the economy are highly intertwined concepts, which are all affecting or constituting the quality of health.

Along these lines, findings confirm all theories connected with respect to the general effects of *galamsey*, I must however be quick to add that they are currently more intense leading to an alarming rate of destruction to the environment.

One common issue that came to light during the interviewing process was the legalisation of these local miners. They indicated that the process of registration was quite complex and bureaucratic hence making it almost impossible to attain the legal permission on the part of these artisanal miners. That according to findings was some of the motives behind people engagement in *galamsey* in the locality; additionally implicating the ecosystem.

This combines with a poor legal framework with regards to the handling of mercury, furthermore as loosely developed policies related to protect mining affected communities exclusivity in small-scale mining in Ghana. In line with Carson et al. (2005), it can be said that the government lacks the mandatory resources, both financially as well as competent manpower to bring a lasting and permanent solution to illegal mining.

This couples with findings indicating that Ghana's relatively high corruption levels function as a compliment to Illegal miners' high susceptibility to use bribing, that additional partially allows them to try and do their work.

Additionally, it has been found that the distribution of the financial gains from mining is poorly done and executed in an unfair manner whereby the grass-root and people negatively affected from mining operations receive the smallest amount comparatively.

The economic benefits of mining cannot be ignored considering the growing global demand for minerals. However, mining should be encouraged in a controlled environment. When mining is controlled or properly supervised, the environmental hazards are vastly minimised.

VI. Recommendations

The government should drastically increase their efficiency with regards to the process of registering as a small-scale miner, as this could increase the amount of registrations, and thus improved mining practices. There is supervision and control when small-scale miners are registered. This will reduce the burden on the environment and the ecosystem as a whole.

In order to hasten the registration process I recommend a thorough decentralisation of the registration process. When registration is accessible, thus as close as the communities that engage in mining, it will help alleviate the stress and frustration miners go through to get registered.

There should also be a considerable effort for the municipal assembly to explore other alternate livelihood support either than mining. Since mining is a non-renewable resource, these minerals are available only for a specific period. In order to reduce the environmental degradation and related vices, there is an urgent need to find alternate jobs. The area of agribusiness can be explored for example, creating income for these households and the community in general.

As indicated earlier in this work, agriculture is the backbone of the populace in the Kwaebibirem District. Considering the traditional primitive ways adopted in farming in the area, the output of the average farmer is not encouraging. I therefore recommend the Ministry of Agriculture in Ghana to lend a supporting hand to these farmers. There is need for some farm inputs like bulldozers, tractors, and sprinklers to enable these farmers cultivate on a large scale. Accessibility of this machinery will go a long way to boost harvest, income and increase in food production countrywide.

Also, there should be policy strategy on land reclamation. Mining laws in Ghana should inculcate the need for proper land reclamation plans at all sectors in the mining industry both small-scale and large scale as in the case of Europe.

Lastly, I recommend an extensive education to all the inhabitants of the community on the effects of illegal uncontrolled mining. It was quite evident during the interviews that

some locals didn’t know how dangerous some chemical like mercury could have on their health. There is the need to educate on the use and proper handling of these dangerous chemicals. Dangers of depleting forests, erosion and water pollution should be well explained in terms that will make sense to the average person.

All paths to development have social, environmental and economic implications which must be evaluated and understood by decision makers, and communicated to those potentially affected (Anderson, 1997).

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