PRESBYTERIAN UNIVERSITY COLLEGE, GHANA
FACULTY OF DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

THREATS TO FOREST RESERVE MANAGEMENT FROM MINING PRACTICES IN TARKWA FOREST DISTRICT, WESTERN REGION, GHANA

BY

DORCAS NYAMA ASIAMAH

SEPTEMBER, 2020

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A Dissertation submitted to the Department of Environmental and Natural Resources Management of the Faculty of Development Studies, Presbyterian University College, Ghana, in partial fulfilment of the requirements for the award of Master's degree in Natural Resources Management

BY

DORCAS NYAMA ASIAMAH

SEPTEMBER, 2020

DECLARATION

Candidate's Declaration

I hereby declare that this dissertation is a result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Name: Dorcas Nyama Asiamah

Candidate's Signature: …………………………………..Date: ………………

Supervisor's Declaration

I hereby declare that the preparation and the presentation of the dissertation were supervised in accordance with the guidelines on supervision of project work laid down by the Presbyterian University College, Ghana

Name: Dr. Mrs. Mary Adu Kumi

Supervisor's Signature: …………………………………..Date………………

ABSTRACT

The study assessed threats to forest reserve management from mining practices in the Tarkwa Forest District of the Western region of Ghana. The study's research design is a qualitative research design. The study uses descriptive survey through which data were gathered from a sample size of 100 respondents which were chosen out of 1000 target population in the Agona, Bonsa and Bonsawere community and also the Forest Services Division of the Forestry Commission all located in the Tarkwa Forest District. Questionnaires being a primary data has been the pivot of data collection instrument in collecting information that relates to the study's topic. It was revealed from the study that, respondents are aware that activities such as ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of mineral ores that are carried out in the forest reserves under the open cast mining processes are those that have serious effects on the Forest reserve. Furthermore, the study revealed that, respondents are aware of the effects that open cast mining have on forest management. Through in-depth interviews with some selected respondents, they claim that, although the mining activities carried out in the forest affects the forest reserve and the environment negatively, they are out of choice since they solely depend on the mining for monetary benefit which they use for their livelihoods. For this problem to be addressed, there is the need for lucrative job opportunities for the community populace which will ease the pressure on inappropriate mining, and comprehensive sensitization of the community members about the future effects that these mining activities have on them.

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To my husband,Simeon Kwasi Asiamah, my brother Emmanuel Oduro Okyere, my mother, Madam Beatrice Asantewa and my children Bernice Owusua Asiamah, Beatrice Asantewa Asiamah, and Susana Yamoaa Asiamah for their immense support, advice and prayers for me during my period of study.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Amponsah -Tawiah *et al* (2011) defined mining as the process of digging into the earth to extract naturally occurring minerals.

Mining is a necessary human activity that has been practiced since the beginnings of human history; however, it clearly has extensive socio-economic and ecological ramifications (McAllister & Fitzpatrick 2010; Worrall *et al.* 2009). Technological advances as well as improvements to mining regulations and management practices have lessened the difficulties associated with mining to some degree and provided great benefits. Even with these improvements mining is still a temporary and often uncertain activity that has potential to lead to long-term environmental issues and regrettable legacy effects (Sandlos &Keeling, 2013).

The West African nation of Ghana like many other countries in the continent was naturally blessed with numerous mineral resources such as gold, diamonds, manganese, bauxite, clays, kaolin, mica, columbite-tantalite, feldspar, chrome, silica sand, quartz, salt etc. (Lawson & Bentil, 2013). The chief deposit of these minerals especially gold and diamond could be mainly found within the forest area of the southern Ghana, the Ashanti region Ghana Minerals Commission (G.M.C), 2010.

Gold production increased within the forest area of the southern Ghana as a result of the arrival of the European traders, and southern Ghana became popularly known as the “gold coast”. The area became one of the most important gold producing area in the world eclipsing other major gold producing areas in West African region of Mali, Bambuk and Boure in the Northern Guinea. The European traders competed vigorously for minerals especially gold for over 400 years1490s till late 1800s, which lead to the sprout of several forts and trading posts along the gold coast (G.M.C, 2010).

The Ghanaian small-scale mining industry is over 2,000 years old. Remnants of alluvial gold extraction and winning activities have been found that date as far back as the sixth century, and there is a wealth of evidence indicating that precious metals recovered from regional artisan activities were attracting Arab traders to certain areas of the country as early as the 7th and 8th centuries AD. In fact, it was the rich gold deposits of the western Sahara that were largely responsible for the wealth and strength of large ancient Ghanaian empires and cultures, and by the 15th and 16th centuries, at the peak of European colonial exploration, Ghana was fittingly labelled the ‘Gold Coast’.

Small-scale mining in Ghana, as in most developing countries, was for decades treated as an informal industrial sector, employing thousands of people but featuring largely rudimentary, unmonitored and uncontrolled practices. Up until the 1980s, small-scale mining activities in Ghana remained largely unregulated and received little, if any, support from governmental bodies. This, however, changed with the implementation of the national Economic Recovery Plan (ERP), which, following years of careful planning, was finally launched in the mid-1980s. In a desperate move to revitalize a stagnating economy, the then Provincial National Defence Council (PRDC) government consulted authorities from both the World

Bank and International Monetary Fund (IMF) to assist in the drafting of national economic plans and policies. The Ghanaian minerals sector was heavily targeted, which, between 1960 and 1980, had experienced mass declines in mineral output: gold production had declined from 900,000oz in 1960 to 232,000oz in 1982; manganese output had dropped from 600,000t in 1960 to 160,000t in 1982; bauxite production declined from 407,000 in 1974 to 64,700t in 1982; and diamond output had declined from 2,340,000 carats in 1975 to 683,524 carats in 1982 (Minerals Commission, 2000). If these exploitations are done in the forest reserve, it has a correlated impact on the forest reserve which is a major problem currently. This can be a major problem for the country years to come because, miners destroy the forest when they mine gold. Therefore, the more they move from forest reserves to forest reserves, they tend to destroy these forest just to achieve their intended purpose which is to mine gold. Mining is important to the economy, but it is associated with destruction, loss of habitats and biodiversity when it is practiced in a forest reserve (Boadi *et al.*, 2016).

1.2 Statement of Problem

Mining activities impact negatively on the environment and the severity of the impact depends on the mining methods used. Mining causes massive damage to landscapes, flora and fauna through the clearing of the top soil to make room for surface mining (Kumi- Boateng *et al*, 2012). Mining activities are going on in the Neung North, Neung South and the Bonsa River Forest reserves in the Tarkwa Forest District. Miners enter the forest reserve to extract gold deposits from existing old abandoned pits dug deep into the ground and leave the forest. The miners can also enter convalescence areas with shovels, hoes, pickaxes to extract gold from areas they detect there are gold deposits. Convalescence areas are areas in a forest reserve which due to either the effects of past logging or fire is now at a stage it cannot be logged in the present management cycle. The area is left to regenerate for 30 or 40 years until commercially sized timber is available for logging. Intensive fire protection is carried out in the area, and enrichment planting also in some selected areas. Collection of Non-Timber Forest Products (NTFP's) in convalescence areas is only restricted to herbs. (MOP, Forest Resource Management Planning in the High Forest Zone, Section A-Strategy Planning, 1998).The miners through their mining activities destroy trees, saplings and trample on the underground seedlings that will grow to replace the felled trees and enrich the area.

In addition, the miners can enter special biological protection areas (SBPA) which are areas in forest reserves provided with full protection for being identified to have a High Genetic Index (GHI) and are intended to provide nature sanctuaries for forest with a large number of rare species. These areas attract large scientific interest and will be registered with the international community. Such areas are fully protected because of their biodiversity, with national and international value. When the miners enter special biological protection areas in the forest reserves, through their mining activities, they destroyed the biodiversity in the area which are fully protected for being rare, found to exist only in the area, and can be used for scientific and research purposes. When biodiversity in SBPA's are destroyed, it defeats the management objective of preserving the area as a special biological protection area.

Furthermore, the miners can also enter swamp sanctuaries and carry out mining activities, if they find gold in the area. Swamp sanctuaries are perennial wet areas that are sustainably managed to maintain water sources, and preserve plants and animals. Felling is not allowed throughout swamp sanctuaries, collection of non- timber forest products (NTFP's) are also prohibited except for those covered under local agreement made between the Forest Services Division and the land owners at the time the management plan was being prepared, hunting and collection of fauna is also restricted in this zone.

When mining is carried out in swamp sanctuaries, it exposes the water sources in the area to evaporation because the trees that were providing cover over the water sources will be destroyed through the mining activities leaving the area bare. Animals in swamp sanctuaries are also left at the mercy of the sun because the trees that were providing shelter for them had been removed and this may lead to their death or movement to other areas. Duran *et al.*, as cited in Owusu *et al.*, (2017) have observed that the negative impacts of mining on the environment and biodiversity may be direct or indirect. Direct negative impacts include habitat loss and fragmentation, killing of wildlife during clearance, disruption of hydrological systems, air and water pollution within and beyond the immediate confines of the mining operations.

Carrying out patrolling duties in mined areas in forest reserves becomes difficult because the exposed water sources, stock piling of top soil, dug pits, trenches, tunnels among others serve as death traps which a forest guard may accidentally fall in and die.

Previous studies have assessed the importance of mining in the country and the impacts the mining activities have on forest if carried out in forest a reserve. Consequently, there is the need to determine how the threats from mining activities affect forest reserve management and the mitigation measures that have to be put in place to control mining practices in forest reserves. It is against this background that the study is being conducted to assess the threats that mining activities in forest reserves have on forest reserve management in the Tarkwa forest district.

1.3 Purpose of the Study

The study is carried out to minimize threats to forest reserve management from mining practices in the Tarkwa Forest District.

1.4 Research Questions

The following are the research questions that guide the study

1. What open cast mining processes are carried out in the forest reserves?
2. What are the effects of the open cast mining practices on the integrity of forest reserves?
3. What measures have been put in place to control the open cast mining practices in the forest reserves?

1.5 Objectives of the study

The main objective of the study is to examine threats to forest reserve management from mining practices in the Tarkwa Forest District. This is achieved through the following specific objectives.

1.5.1 Specific Objectives

1. To examine the processes used for open cast mining in the forest reserves.

2. To analyze the effects of open cast mining practice on the integrity of forest reserves.

3. To evaluate the measures put in place to control open cast mining practices in the forest reserves.

1.6 Significance of the Study

This study assesses threats to forest reserve management from mining practices by looking at how open cast mining activities are carried out in the forest reserves. It will also look at how the open cast mining activities have affected the integrity of the forest reserves, and their management. It will examine measures put in place to control the open cast mining practices going on in the forest reserves. The results will serve as an important reference material for the government and other regulatory bodies. The reference material will guide them when making policies, enacting laws relating to allocation of mining concessions to prospective investors in forest reserves. The study will also provide relevant information on how to mitigate open cast mining practices in forest reserves in the Tarkwa Forest District. This can also be used to address similar problems in forest reserves in other areas.

1.7 Delimitations of the study

Specific scope was set for the study by focusing on the relevant stakeholders depending on the forest and concern with forest management in the Tarkwa forest district. Attention was given to the processes of open cast mining, the effects of open cast mining on the integrity of forest reserves and the measures put in place to control the open cast mining practices in the forest reserves. Field studies were carried out for a period of three months. Information was collected from forest fringe communities, and the Forestry Commission to obtain information about threats to forest reserve management from open cast mining practices and also obtain suggestions that could help mitigate open cast mining activities in forest reserves in the Tarkwa forest district.

1.8 Limitations of the study

The study examines threats to forest reserve management from mining practices. There are other factors that serve as threat to forest reserve management. Since open cast mining activities had been chosen as the threat for the study, the focus must be on open cast mining activities. The data collected centered on open cast mining activities as threats to forest management. Including other causes of threats in the study makes the work interesting, since it provides diverse information on the various threats to forest management, but it makes the work very bulky. Therefore, the study does not allow other issues outside the scope to be included and this is considered a limitation to the study.

1.9 Organization of the study

The study is organized into five chapters. The first chapter is the introductory chapter. It covers the background of the study, statement of the problem, purpose of the study, research questions/hypothesis/assumptions, significance of the study, delimitations of the study, limitations of the study, the objectives of the study and organizations of the chapters. Chapter Two deals with the literature review of the theme of the study. Chapter Three which deals with the methodology of the study describes the study area, research method to apply, data collection procedure and data analysis. Chapter Four deals with the results and discussions of the study. Chapter Five entails the overview of the study, key findings, recommendation for policy and practice and suggestions for further research.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 Introduction

In this chapter, systematic review of literature from textbooks, academic journals, conference papers, institutional and stationary publications are used to explain what mining entails, types of mining, methods of mining, effects of gold mining on the environment, stages of gold mining, forest management practices, benefits derived from forest to mankind and the environment, the impact of mining on forest reserve management, the effects of open cast mining on forest reserve management, the effects of open cast mining on the integrity of forest reserves, sustainable forest management and biodiversity conservation and forest management planning for sustainable tropical forest management.

2.1 Mining

Mining is the extraction of economically valuable minerals or other geological materials from the earth surface. It may be from an ore body, lode, vein, seam, reef, or placer deposit (Balasubramanian, 2017).

2.1.1 Types of mining

Amponsah-Tawiah *et al* (2011) mentioned the two main types of mining as underground and surface mining.

Surface mining is the type of mining carried out when the mineral deposit lies on the surface of the earth. It is more cost effective and needed fewer workers to produce the same quantity of ores produce by underground mining

Amponsah -Tawiah *et al*(2011). Mensah *et al* (2015) explained surface mining as the dominant method used by small scale mining artisans due to it cost effectiveness, low capital intensity and minimal technical skill requirement. Amponsah-Tawiah *et al* (2011) mentioned underground mining as the type of mining used when the mineral deposit lies deep below the surface of the earth. Ores that are buried in bedrock deposits are usually accessed through the construction of access shafts and tunnels. Balasubramanian (2017) also disclosed that underground mining provide less waste rock removal and offer less environmental impact as compared to surface mining because these deposits typically have much higher ore grades. There are several methods of surface and underground mining.

2.1.2 Methods of mining

Mining has several methods and these can be categorized under the two main types of mining namely surface mining and underground mining. In the surface mining, the two most common types are open-pit mining and strip mining. Open pit mining is the common type of surface mining. Open pit mining involves digging out rocks to form an open pit or borrow pit, from which resources are then extracted (Smith, 2019). The pit in an open-pit mine is created by blasting with explosives and drilling. This type of mining is typically used to mine gravel and sand and even rock, when open-pit mining is used to extract rock from the earth, the pit is often called a "quarry". Open pit mines are typically worked until either the mineral deposit is depleted, or various factors make the mine non-profitable. These pit mines continue to be enlarged until there is no more ore to mine or the overburden becomes too heavy. When this occurs and it is no longer economical to operate an open-pit mine, open pit is often modified to become a landfill for solid wastes. The pros of an open pit mine is that these mines usually produce a vast amount of ore without the costly process of removing overburden the ore is often in a large area and close to the surface. However, a major con of these type of mines is that they are both dangerous to work in, and permanently alter the surrounding ecosystem (Dalto, 2017).

Strip mining is the process of removing a thin strip of overburden earth above a desired deposit, dumping the removed overburden behind the deposit, extracting the desired deposit, creating a second, parallel strip in the same manner, and depositing the waste materials from that second strip onto the first strip. Soil, rock, and vegetation over the mineral seam is removed with huge machines, including bucket-wheel excavators. This type of mining makes sense when the mineral is near the surface. If the ore is too far under the surface, the process of strip mining becomes impractical and needlessly damaging to the terrain.

There are two types of strip mining depending on the amount of ore under the surface and surrounding terrain. These are Area stripping and Contour stripping.

Area stripping extracts ore over a large, flat terrain in long strips. The overburden of rocks and soil is dropped in the previous strip so that long gaps are not left in the earth after mining is complete and Contour mining is a version of strip mining that follows the contours of outcrops and hilly terrains. Usually, the mineral seam follows the contour of the outcrop, and the overburden is removed carefully along the seam in much smaller and custom shaped excavations rather than long strips.

Other methods of mining under the surface mining includes in-situ-mining, placer mining, mountain removal mining, high wall mining, hydraulicking and dredging.

In-situ mining also referred to as solution mining, in-situ mining does not involve removing intact ore from beneath the earth's surface. Instead, it involves pumping chemicals underground to dissolve resource-containing ore and then pumping what is known as the "pregnant solution" back up to the surface, where it can be processed to recover minerals. This technique is mainly used in uranium mining.

This technique causes very little disturbance to the surface and does not produce large amounts of waste rock. To use this technique, the ore body must be permeable to the extraction liquids, and it must be possible to complete the process without the significant risk of contaminating nearby groundwater (Smith, 2019).

Placer mining is normally formed by weathering via water and/or wind action, placers are unconsolidated deposits of resources. Placer mining is generally done in riverbeds, sands or other sedimentary environments and involves sifting valuable materials from sediments. Famously, "panning for gold" can be part of the placer mining process. In placer operations, the extracted sedimentary material is rinsed and sluiced to pull out the desired minerals. Placer mining is used to sift out valuable metals from sediments in river channels, beach sands, or other environments.

In addition to gold, gemstones, platinum, tin and other materials can be extracted via place mining. At least 50 percent the world's titanium comes from this type of mining operation (Smith, 2019).

Mountaintop removal mining is highly controversial, and best suited for retrieving mass amounts of minerals, usually coal, from mountain peaks. The process involves blasting the overburden with explosives above the mineral seem to be mined. The broken mountaintop is then shifted into valleys and fills below.

This type of mining is used when the ore to be retrieved is 400 feet or deeper. Controversy surrounds the permanent alteration of ecosystems and entire landscapes by removing mountaintops, however, advocates point out that after completion the mining process leaves a flat terrain where there wasn't one when reclamation is complete. (Dalto, 2017)

High wall mining relies on machinery to collect ores from a "high wall", or an unmined wall with overburden and exposed minerals and ores. Usually, high walls are found at the edges of quarries and pit mines, and enable miners to retrieve ore from a wall that would otherwise be too expensive to clear of overburden in order to reach the ore. It's also used in contour strip mines to retrieve additional ore from the mineral seam above the created terrace.

An expensive and remotely controlled high wall mining machine excavates in a tight square from the face, using continuous drilling. Conveyor belts and pulleys move the matter from the drill through the device and the leftover matter is deposited behind the drill (Dalto, 2017).

Dredging is the process of mining materials from the bottom of a body of water, including rivers, lakes, and oceans. Dredging is the more sophisticated version of panning for gold. In fact, it's mostly associated with gold mining. Much like hopeful miners with their pans during the gold rush, floating dredges (a barge fitted with conveyor belts and scoops) move up a water table. A scoop lifts material up on a conveyor belt, and the mineral is removed on board the barge. The unwanted material is then dropped back into the water table using another conveyor belt.

Underground methods which includes unsupported, supported, and caving are differentiated by the type of wall and roof supports used, the configuration and size of production openings, and the direction in which mining operations progress. The unsupported methods of mining are used to extract mineral deposits that are roughly tabular (plus flat or steeply dipping) and are generally associated with strong ore and surrounding rock (Howard *et al.*, 2002).

These methods are termed unsupported because they do not use any artificial pillars to assist in the support of the openings. However, generous amounts of roof bolting and localized support measures are often used. Room-and-pillar mining is the most common unsupported method, used primarily for flat-lying seams or bedded deposits like coal, trona, limestone, and salt. Support of the roof is provided by natural pillars of the mineral that are left standing in a systematic pattern. Stope-and-pillar mining, a stope is a production opening in a metal mine) is a similar method used in noncoal mines where thicker, more irregular ore bodies occur; the pillars are spaced randomly and located in low-grade ore so that the high-grade ore can be extracted (Howard *et al*., 2002). These two methods account for almost all of the underground mining in horizontal deposits in the United States and a very high proportion of the underground tonnage as well. Two other methods applied to steeply dipping deposits are also included in the unsupported category. In shrinkage stoping, mining progresses upward, with horizontal slices of ore being blasted along the length of the stope. A portion of the broken ore is allowed to accumulate in the stope to provide a working platform for the miners and is thereafter withdrawn from the stope through chutes. Sublevel stoping differs from shrinkage stoping by providing sublevels from which vertical slices are blasted (Howard *et al.*, 2002). In this manner, the stope is mined horizontally from one end to the other. Shrinkage stoping is more suitable than sublevel stoping for stronger ore and weaker wall rock. Supported mining methods are often used in mines with weak rock structure. Cut-and-fill stoping is the most common of these methods and is used primarily in steeply dipping metal deposits. The cut-and-fill method is practiced both in the overhand (upward) and in the underhand (downward) directions. As each horizontal slice is taken, the voids are filled with a variety of fill types to support the walls. The fill can be rock waste, tailings, cemented tailings, or other suitable materials. Cut-and-fill mining is one of the more popular methods used for vein deposits and has recently grown in use. Square-set stoping also involves backfilling mine voids; however, it relies mainly on timber sets to support the walls during mining (Howard *et al*, 2002). This mining method is rapidly disappearing in North America because of the high cost of labor. However, it still finds occasional use in mining high-grade ores or in countries where labor costs are low. Stull stoping is a supported mining method using timber or rock bolts in tabular, pitching ore bodies. It is one of the methods that can be applied to ore bodies that have dips between 10° and 45°. It often utilizes artificial pillars of waste to support the roof (Howard *et al*, 2002). Caving methods are varied and versatile and involve caving the ore and/or the overlying rock. Subsidence of the surface normally occurs afterward. Longwall mining is a caving method particularly well adapted to horizontal seams, usually coal, at some depth. In this method, a face of considerable length (a long face or wall) is maintained, and as the mining progresses, the overlying strata are caved, thus promoting the breakage of the coal itself. A different method, sublevel caving, is employed for a dipping tabular or massive deposit. As mining progresses downward, each new level is caved into the mine openings, with the ore materials being recovered while the rock remains behind (Howard *et al.*, 2002). Block caving is a large-scale or bulk mining method that is highly productive, low in cost, and used primarily on massive deposits that must be mined underground. It is most applicable to weak or moderately strong ore bodies that readily break up when caved. Both block caving and longwall mining are widely used because of their high productivity. In addition to these conventional methods, innovative methods of mining are also evolving (Howard *et al.*, 2002). These are applicable to unusual deposits or may employ unusual techniques or equipment. Examples include automation, rapid excavation, underground gasification or liquefaction, and deep-sea mining.

2.1.3 Effects of Gold Mining on the environment

Several mining engineers including Balasubramanian (2017) have observed mining to be commonly associated with a variety of environmental problems including water pollution, radioactive tailings, erosion, sinkholes, biodiversity loss, and soil contamination. Additionally, groundwater and water can be contaminated by chemicals from processing or leakage. Mineworkers are conceivably dependent upon risky conditions together with openness to dangerous gases, emission openness, loss of power, imploding burrows, dust inward breath and harmful spill over. Mensah *et al.* (2015) also mentioned contamination of water bodies leading to loss of aquatic organisms, destruction of biodiversity, removal of vegetation, depletion of soil as the effects of mining on the environment, with magnitude of the damage based on the mining methods used.

2.1.4 Stages of Gold Mining

Balasubramanian (2017), stated that the overall sequence of activities in modern mining consist of five stages which are Prospecting, Exploration, Development, Exploitation and Reclamation. Prospecting which is the first stage in the utilization of a mineral deposit is the search for ores or other valuable minerals both coals and other non-metallic. Mineral deposits may be located either at or below the surface of the earth because of this, both the direct and indirect techniques are employed. The direct method of discovery, which is normally limited to surface deposits consists of visual examination of the exposure of the deposit or the loose fragments that have weathered away from the outcrop. In the direct method, the geologist gathers information about the entire area from aerial photography, geologic maps and structural assessment of the area to locate mineral deposit. Precise mapping, structural analysis and microscopic studies of samples can also be used to locate hidden as well as surface mineralization (Balasubramanian, 2017).

In the indirect method, the geologist applies the sciences of geophysics, geochemistry and geobotany using aircraft and satellites on the surface or beneath the earth, quantitative analysis of soil, rock, water samples and the analysis of plant growth patterns to determine the location of a mineral deposit and the exact mineral composition of a sample and the ore grade (Balasubramanian, 2017).

Balasubramanian (2017) explained exploration as the second stage in the life of a mine that determines accurately the size and value of a mineral deposit using techniques similar to but more refined than those used in prospecting. In exploration a variety of measurements are used to obtain a more positive picture of the extent and grade of the ore body on the surface and subsurface locations. The representative samples which are obtained by chipping out crops, trenching, tunneling and drilling are subjected to chemicals, metallurgical, X' ray or radio metric evaluation techniques to enhance the investigators knowledge on the mineral deposit.

Development which is the third stage of mining is the work of opening the mineral deposit for exploitation. Access is gained to the mineral deposit by either stripping the overburden which is the soil or rock covering the deposit to expose the near surface ore for mining or by excavating the opening from the surface to access more deeply buried deposits to prepare for underground mining (Balasubramanian, 2017).

Balasubramanian (2017) revealed that preliminary work required before development takes place include acquiring water and mineral rights, buying surface lands, arranging for financing, preparing permit application and environmental impact statement. It also involves the provision of access roads, power sources, mineral transportation systems, mineral processing facilities, waste disposal areas, offices and other support facilities. Other environmental and legal considerations taken into accounts are the stripping ratio, the ratio of waste removed or recovered. The kind of mineral being mined and therefore the encompassing natural environmental conditions are likewise considered while deciding the hardware, ventilation frameworks, power supply and water supply of the amenities.

Exploitation is the fourth stage of mining, and it is associated with the actual recovery of minerals from the earth in quantity. Normally, sufficient improvement is done before misuse to guarantee that creation, as soon as commenced can proceed continuously for the duration of the existence of the mine. Geologic conditions such as the dip, shape and the strength of the ore and the surrounding rock play a key role in selecting the method (Balasubramanian, 2017).

Reclamation the final stage of a mine is the process of closing a mine and re-contouring, re-vegetating and restoring the water and land values. The best and ideal opportunity to start the recovery method of a mine is before the principal unearthing are started. In getting ready for the recovery of some random mine, there are numerous issues that should be tended to. The safety of the mine site is the first issue to be considered. On the off chance that the region is available to the overall population, the evacuation of workplaces, process facilities, transportation gear, utilities and alternative surface constructions should by and large be refined. Any existing high walls or other geological structures may require mitigation to prevent injuries or death due to geological failure (Balasubramanian, 2017).

Balasubramanian (2017) emphasized on the second major issue to be addressed during reclamation of a mine site for the restoration of land surface, the water quality, and the waste disposal regions so that drawn out water contamination, soil disintegration, and dirt generation or vegetation issues do not happen.

2.1.5 Forest management practices

Forest Management is the way toward arranging and actualizing practices for the stewardship and utilization of woodlands to meet explicit environmental, economic, social and cultural purposes. It manages the administrative, economic, legal, social, specialized and scientific elements of overseeing natural and planted forests. It might include changing levels of purposeful human mediations, going from activities aimed toward protecting and keeping up woodland environments and their capacities, to those preferring explicit socially or economically significant species for the improved creation of woodland products and services (FAO, 2020).

Forest resources and forest lands should be sustainably managed to meet the social, economic, cultural and spiritual human needs of present and future generations. There is the need for forest products and services such as wood and non-wood products, water, food, fodder, medicine, fuel, shelter, and employment creation, habitat for wildlife, landscape, biodiversity, carbon sinks and reservoirs among others. Therefore, appropriate measures should be taken to protect forest against harmful effects of pollution, fires, pests, and diseases in order to maintain their full values. According to the manual of procedures, forest resource management planning in the high forest zone section B-Operational Planning, (1998).The processes of forest management are Protection, Management, and Development.

Protection involves forest boundary maintenance, boundary inspection, boundary planting, boundary pillaring, patrolling and fire protection, construction and maintenance of rides among others. The following are some of the activities that are carried out under protection to protect the integrity of our forest reserves. Boundary cleaning is carried out along the external and internal boundaries of forest reserves by forest guards to prevent the boundaries from weeds and enhance accessibility. It prevents fire outbreaks from the off reserve from entering the forest reserve. It also prevents spreading of fire from the external boundaries to other parts of the forest reserve. Inspections are carried out on the external and internal boundaries to ensure they are cleaned. Forest guards also carry out patrolling in the forest reserve to detect offences. Patrolling are intensified during the dry season to enable early detection of fire outbreaks in the forest reserve.

Planting of tree seedlings on the external and internal boundaries of forest reserves are carried out during the rainy season to ensure maximum survival of the seedlings. Seedlings that did not survive are replaced with new ones to ensure uniformity among the seedlings. Planting along the forest reserve boundaries are carried out to differentiate the reserve from the off reserve. Fire rides are constructed and maintained in forest reserves to prevent fire outbreaks in a compartment from spreading to other compartments and also provide accessibility.

Boundary pillaring is carried out on the external, internal and compartments boundaries within forest reserves. The external boundary pillars are normally located at the periphery of forest reserves, internal boundary pillars are located along admitted farms or villages within the reserve and compartment boundaries are also found along compartments within forest reserves. Broken and defaced concrete boundary pillars are also replaced with new ones. Boundary pillaring makes identification of a location in the forest reserve easy, because it relieves the pain of combing through the whole forest reserve to identify an area. It also prevent encroachers from taking part of the forest reserve, because it enable foresters know the legal boundaries of their forest reserves.

Management entails demarcation of compartments and protection areas, identification of timber utilization contract (TUC'S), stock surveys, monitoring and supervision of logging among others. Manual of procedures (MOP), Forest resource management planning in the high forest zone (HFZ) section B-Operational Planning (1998).Demarcation of compartments and protection areas in forest reserves are carried out to ease management in a forest reserve. Stock survey is carried out in a compartment in a production area within a forest reserve suitable for harvesting to obtain information on mature tree species, identify species that can be harvested, areas that should not be disturbed during harvesting and to assist with the harvesting planning (MOP, Forest resource management planning in the HFZ section C-Sustainable Timber production on reserve).

Selected mature trees after yield calculation and approval are given out to qualified timber contractors on a timber utilization contract to harvest for 30 or 40 years depending on the mean basal area per hectare of the production forest area. Thus, if the mean basal area is less than $25m^3$per hectare, a 30 year felling cycle is prescribed. Alternatively, a 40 year felling cycle is prescribed, if the mean basal area is more or equal to $25m^3$per hectare (Revised timber yield regulation, 2020).Monitoring and supervision of logging is carried out by the Forest Services Division to ensure the contractor does the harvesting of trees according to the felling regulation (MOP, Forest Resource Management Planning in the High Forest Zone Section C-Sustainable Timber production on reserve).

Development involves nursery establishment, plantation establishment, enrichment planting, beating up, tending, thinning, and pruning among others. Nurseries are established to produce either bare-rooted/ potted tree seedlings for plantation establishment, amenity, avenue and recreational planting. Seedlings are mainly produced from seeds collected from mother trees with good phenophytic characters. Vegetative propagation can also be used to produce seedlings from cuttings of stems, roots and leaves among others.

Plantations are established in degraded areas in forest reserves to improve the stocking level through the taungya system or enrichment planting. The Taungya system involves the establishment of forest plantation by the Forestry commission in partnership with farmers in forest fringe communities. In this system, the farmers are given the right to cultivate food crops during the early stages of the forest plantation development. Food cultivation is often discontinued when the trees form canopy and shade the food crops (Ghana Forestry Plantation Strategy, 2016).

Enrichment planting is a forest restoration intervention aimed at enhancing the commercial productivity and functionality of a degraded forest. It is done where there are insufficient numbers of economically viable trees, in the natural stand. It is carried out by gap planting or line planting of trees in the forest to improve the stocking, functions and resilience of the degraded forest. It can be carried out with the field staff or people from the forest fringe communities. (Ghana

Forestry Plantation Strategy, 2016).Beating up or replanting is carried out to replace dead or weak seedlings in a forest nursery or plantation. Seedlings used for beating up should be of the same size with the growing seedlings in order to ensure uniformity among the seedlings.

Tending is carried out in forest plantations to free planted seedlings from competition from weeds. It is carried out either manually or mechanically depending on the nature of the weeds. Thinning is done in plantations to remove crooked, broken, and diseased trees in order to reduce competition and enable the remaining trees grow well to produce final crops of commercially desirable diameter. Pruning is also carried out in forest plantations to improve the quality of the stands by producing smooth knot- free boles. Some of the above forest management activities are likely to be affected if there are activities going on in a forest reserve that poses threat to forest management.

The following are some examples of areas demarcated in forest reserves and strategically managed to ensure sustainability of the forest resources. Hill sanctuaries, Swamp sanctuaries, Provenance Protection Area, Special Biological Protection Area, Convalescence Forest Areas, Timber Production Areas, Non-Timber Production Areas, Plantation Production Areas, Conversion or Plantation Development areas(Manual of Procedures, Forest Resource Management Planning in the High Forest Zone Section A Strategic Planning 1998).

Hill sanctuaries are lands within a forest reserve where the slope is greater than 30%. These areas are strategically managed to provide environmental protection of steep slopes, water sheds and also to provide an extensive area of protection of undefined species of both flora and fauna.((Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone Section A-Strategic Planning, 1998).

Swamp sanctuaries are perennial wet areas within forest reserves which are strategically maintained for the maintenance of water sources (Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning, 1998).Provenance Protection Areas are areas in forest reserves with high population of key economic species. They are strategically managed to act as gene banks for exploited species ((Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning 1998).Special Biological Protection Areas (SBPA's) are areas where the forest has been identified to have a high genetics heat index (GHI) and intended to provide nature sanctuaries for forest with a large number of rare species that will be registered with the international community (Manual of procedures, forest resource management planning in the high forest zone section B-Operational Planning, 1998).

Convalescence Forest Areas are areas within a forest reserve which due to either the effects of past logging or fire is now at a stage where it cannot be logged in the present management cycle. Such areas are left to regenerate until commercially sized timber is available for felling (Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone-Section A-Strategic Planning. Timber Production Areas are healthy productive forest greater than $25m^3$ per hectare basal area which does not fall into a protection zone or a non-timber forest product (NTFP) designated area. Timber production areas are strategically managed to produce sustainable timber production (Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning1998).

Non-Timber Forest Product Areas are identified by right holders as important NTFP collecting grounds which do not fall into the protection designation areas. They are strategically managed to provide sustainable production of NTFP's for local and commercial use. ((Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning1998). Plantation Production Areas are areas consisting of stands that were artificially regenerated. Plantations in these areas were established using seedling stock, and managed using well tested silvicultural principles such as beating up/replacement of dead seedlings, tending, thinning, pruning and thinning of final felling to maximize production of materials of commercially desirable diameters ((Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning 1998).

Conversion or Plantation Development areas are areas where the forest cover and regeneration is minimal and might be suitable for conversion to plantations. These areas are considered degraded and placed under conversion and extensive plantations establishment in order to restore the tree cover, environmental functions and also generate revenue for the resource owners (Manual of Procedures (MOP), Forest Resource Management Planning in the High Forest Zone- Section A-Strategic Planning1998). These areas are likely to be affected if activities going on in the forest reserve poses threat to forest management.

The study therefore aims at finding out how mining practices have affected sustainable forest management practices in the Tarkwa Forest District.

2.2 Benefits of Forest Conservation to Mankind and the Environment

Globally, intact forests provide a variety of provisioning and regulating services essential to social and ecological integrity on multiple spatial scales (Scullion, Vogt, Sienkiewicz, Gmur & Trujillo, 2014; Reid *et al*., 2013). For instance, forest ecosystem services provide climate regulation, carbon storage and sequestration, pollution control, nutrient cycling, and hydrologic regulation (Ellison, 2017). Forests also provide socio-cultural value for certain groups, as well as economic consumptive use and non-use (e.g., aesthetic) values (De Groot, Alkemade, Braat, Hein & Willemen, 2010). Locally, woodland sites are witness to the different land utilizes which stability these biological, socio-cultural, and economic services

Yet, despite ecosystem resilience depending on landscape heterogeneity and continuity (De Groot *et al*., 2010, many of the world's remaining intact forests are threatened by deforestation or fragmentation by human activities including logging, hunting, and mineral extraction, for consumptive use at the loss of crucial social and ecological services. The fast development of annihilated or changed sites, especially in tropical woods, has brought about calls for preservation procedures stretching from the advent of secured regions, sites passageways, and buffer zones (Soares-Filho *et al*., 2010; Vuohelainen, Coad, Marthews, Malhi & Killeen, 2012), to community forest management and payments for ecosystem services (Kaczan, Swallow & Adamowicz, 2013). Forests supply people with products we need to survive and others we desire to be more comfortable (Akabzaa & Dramani, 2010). Hirons (2013) noted that forests are a home to considerable proportion of global biodiversity, and play a significant role in the global carbon cycle serving to ameliorate the impacts of climate change. Properly managed forests are therefore synonymous with popularized notions of sustainable development - namely, addressing the triune concerns of economic growth, societal flourishing and environmental protection. The increasingly central role of forests in the pursuit of sustainable development is captured by the subtitle of the latest Food and Agricultural Organization's (FAO, 2012) State of the World's Forests report: 'Forests at the heart of a Sustainable Future'.

As one of the most diverse and prevalent ecosystems, forests fulfil multiple environmental, social, economic and cultural roles in many countries. Forest cover is a strong indicator of sustainable development (UNEP, 2010). A continuously fast declining proportion of forest area is an indication of unsustainable practices in the forestry and agricultural sector. There was a significant change in the proportion of land area covered by forest between 1990 and 2010. In 15 countries of Africa, forests covered no more than 10 per cent of the total land area in 2010 (FAO, 2010). These include all countries in North Africa except the Sudan and Morocco which are often referred to as low forest cover countries. The underlying causes of deforestation are multifaceted and diverse, ranging from pressure to convert land to agriculture, to marginalization of the poor who harvest forest resources unsustainably for their survival (United Nations Economic Commission for Africa (UNECA), 2013).

A full understanding of the underlying causes and how they link to other sector policies and incentives is needed to halt and reverse forest loss and degradation. For instance, understanding the link between agricultural expansion policies and deforestation will lead to integrated planning that takes into account the negative impact of agricultural policies on other natural resources (UNECA, 2013).

Forests also protect fragile ecosystems such as mountains and wetlands important for biodiversity and are often planted to protect sensitive sites acting as riparian buffer zones, galleries, barriers, shelterbelts and windbreaks to ecosystems (Gobez, Bekele, Lemenih & Kassa, 2011).The Congo Basin, the second largest contiguous expanse of tropical rainforest in the world, accounts for 65 per cent of Sub-Saharan Africa's biodiversity (Gondo, 2010). The resultant biodiversity in forests provides key ingredients and raw materials or germplasm for biotechnology while also presenting suitable ecosystems for nature tourism. Forests are key tourist attractions and habitats for major wildlife and unique sceneries popular with tourists to Africa. Limited data is available in Africa at various levels on how forests promote different dimensions of sustainable development, including a wide range of economic, environmental, social and cultural benefits.

2.3 The Impact of Mining on Forest Reserve Management

Forests in Ghana are concentrated in the high forest zone (HFZ), which broadly covers the southern third of the country. The HFZ contains 216 state reserves which cover 1.7million hectares. However, only 2% are said to be in excellent condition, with approximately half being in reasonable condition or better. The remaining half is mostly degraded or worse. There are about 0.4 million ha of off reserve forest spread across a 5 million ha area, and it is in these areas where most deforestation and degradation has occurred (Osafo, 2010).

The same broad geographic area, the southern third of Ghana, is also where the majority of mining activities are located. Overlaying the complex forest mosaic is an equally complex series of concessions for different stages of the mining process, such as prospecting, exploration and exploitation. Notwithstanding the enormous scope concessions, there are currently more than 800. 25 ha small-scale mining licenses in the country which represent an estimated 10% of all Artisanal Small scale Mining (ASM) activity, the remainder working informally. Small-scale mining activities frequently overlap with forested areas because alluvial deposits, which are most suitable geologically, are concentrated around river bodies. River bodies for which many timberland saves were organized to secure. Mining appears to pose an enormous problem on sustainability of the host communities. Third World Network Africa (2011) observes that, the mining industry carries with it cost, such as environmental degradation as well as social problems in local communities that need to be taken into account in any cost- benefit analysis of the contribution of the sector to the national economy and development objectives. As stated by Aubynn (2012), theories such as “resource dependency” and “resource curse” have been applied to answer the questions or problems in resource communities. To some extent, these theories best relate to less developed economies, where most of the companies operating in the communities are extra-local with no obligation to invest in the community (Aubynn, 2012).

Ambali (2010) indicated that, it is an obvious truth that mining spoil the natural beauty of areas that are producing the precious mineral like gold. He put forth a sarcastic analogy that one cannot eat the nitrous yellow yolk of an egg without breaking the shell, meaning the positive impact of mining cannot be enjoyed without a cost. That is, despite the well-known minuses related with mining. There are some positive impacts (Lahiri-Dutt, 2013; Akabzaa and Dramani, 2010). Also Lahiri-Dutt (2013), stated that large scale mining leads to influx of migrants into the community resulting in urbanization and an overall higher standard of living; building of more infrastructures; increasing access to training and better employment opportunities. It increases economic opportunities and the youth also aspiring for better futures within the region (Goldfields Annual Report, 2013).

Effects of mining are harder to evaluate at the worldwide scale. Mining directly emits carbon, as does associated mineral processing activities, negatively affecting biodiversity via anthropogenic climate change (Fischedick *et al*., 2014; Scheffers *et al*., 2016). Mineral supply chains can have extensive, yet often hidden impacts on biodiversity (Lambin *et al*., 2018). Although not at the global scale, steel making in Brazil causes extensive habitat loss in the sourcing of non-mineral resources (Sonter, Barrett, Moran & Soares, 2015). Other research suggests that supply chains and global trade can have extensive ecological footprints (Moran, Petersone & Verones, 2016); however, consequences for biodiversity remain largely unknown.

2.4 Effects of Open Cast Mining Practice on the Integrity of Forest Reserves

Mineral processing activities involve the use of substances like cyanide and generate by-products, which can be harmful to the environment and create other risks; for instance, geological uncertainty such as collapse of pit wall (Mines & Communities, 2017). Again, it poses risks to sustainability of many people. These include landlessness, homelessness forced relocation, loss of income from traditional sources, loss of access to communal resources vital for survival, cultural destabilization, food insecurity and health degradation. Other risks are marginalization, corrosion of the community sovereignty, disruption of the social organization and traditional leadership, spiritual uncertainty, restriction of the civil and human rights, limitation of the capacity to participate in the broader economy/society, and threats from environmental disaster-exposure to noise, vibration, contaminated ground water and pollution due to dust and gaseous emissions (Lahiri-Dutt, 2013; Boateng, 2011; Veiga *et al.*, 2011; Akabzaa & Dramani, 2010).

Akabzaa & Dramani (2010), extensive areas of land and vegetation in Tarkwa have been cleared to make way for surface mining activities. Currently, open cast mining concessions have taken over 70% of the total land area of Tarkwa. It is estimated that at the close of mining a company would have utilized 40-60% of its total concession space for activities such as siting of mines, heap leach facilities, tailings dump and open pits, mine camps, roads, and resettlement for displaced communities (Akabzaa & Dramani, 2010). This unfavorably affects the land and vegetation, the primary wellsprings of work of individuals. There is already a scramble for farmlands in Atuabo and Dumasi.

In many portions of Tarkwa, the surroundings goes through fast shocking conditions and its enormous economic worth is diminishing from one year to another, due essentially to the hefty centralization of mining exercises nearby. Farming grounds are by and large debased, however the deficiency of land for agricultural production has likewise prompted a shortening of the unplanted period from 10-15 years to 2-3 years. The conventional bush unplanted system, which adequately reused generous measures of nutrients and made the following cycle beneficial, can presently don't be drilled because of inadequacy of land. Large-scale mining activities generally continue to diminish the vegetation of the area to levels that are vicious to biological diversity (Akabzaa & Dramani, 2010).

Also, in Prestea, one of the mining communities in Ghana, increased mining activities have resulted in disproportionate contamination of major water bodies leading to loss of aquatic organisms, destruction of the biodiversity, removal of vegetation, depletion of soil resources and loss of farmland. For instance, a study by (Serfor-Armah, Nyarko, Dampare & Adomako, 2016) in Prestea, found high levels of arsenic and antimony concentrations in the rivers ranging from 0.90 – 8.25 ppm and 0.09 – 0.75 ppm respectively, far exceeding the World Health Organizations recommended values of 0.01 and 0.005 ppm respectively. Again, (Singh, Koku & Balfors, 2015) reported a spillage caused by BGL (Bilington Bogoso Gold now called Golden Star Resources Bogoso/Prestea Limited) on 23 October 2004, a major surface mining company found in the area. This spillage, according to (Singh *et al*., 2015), emanated from the new tailings dam of the company into the River Aprepre, which flows into other rivers, including Egya Nsiah, Bemanyah, Manse and Ankobra. They showed that the cyanide spillage influenced Dumasi and distinct some other towns, including Goloto, Juaben and Egyabroni and that a few occupants of Dumasi and other towns around there got and ate dead fish, crabs, shrimps and other amphibian life forms that were discovered drifting on the outside of the river

2.5 Sustainable Forest Management and Biodiversity Conservation

Sustainable forest management is the way toward overseeing lasting forest land to accomplish at least one obviously specified objectives of the executives as to the creation of consistent progression of wanted woodland products and services without excessive decrease of it inalienable qualities and future efficiency and without unnecessary unwanted impacts on the physical and social environment. (Ghana Forest Plantation Strategy, 2016)

Biodiversity conservation and sustainable use with equitable sharing of benefits derived from its natural services are the basis of human well-being (Convention of Biological Diversity (CBD), Secretariat 2010). The goods and services realistic from natural resources, including fundamental biological system administrations, can form the improvement ways of a country, while improvement decisions thusly decide the destiny and state of biodiversity and ecosystem services. Like elsewhere in the globe, the most important threats to biodiversity have long been habitat loss, due to large-scale conversion of land to agriculture and urban centres, introduction of unknown intrusive species, over misuse of natural resources and contamination. Africa is home to eight of the world's 34 biodiversity hotspots: Cape Floristic Province, Coastal Forests of Eastern Africa, Eastern Afromontane, Guinean Forests of West Africa, Horn of Africa, Madagascar and Indian Ocean Islands, Maputaland-Pondoland-Albany and the Succulent Karoo (UNEP, 2011).

Mining influences biodiversity at numerous spatial scales (site, landscape, local and worldwide) through direct mineral extraction and ancillary cycles by means of businesses supporting mining tasks, and outside partners who access biodiversity-rich territories as the aftereffect of mining to date, most exploration has analyzed effects at the site-level, arising straightforwardly inferable to habitat loss and degradation. This focus is unsurprising, given that site preparation for mine expansion and waste management is a destructive process, changing abiotic and biotic conditions (Asner, Llactayo, Tupayachi & Luna, 2013;Wickam *et al*., 2013), and in some cases singlehandedly causing region-wide declines in rare and threatened species and ecosystems (Jacobi, do Carmo, Vincent & Stehmann, 2010; Ganzhorn, Goodman & Vincelette, 2011).

Effects on biodiversity additionally arise across landscapes and regions. Research at this scale has focused on the direct impacts of chemical and physical, dust and aerosols mining waste discharge; chemical emissions include mercury or cyanide used to extract gold (Malm, 2010). When some ores are exposure to the air acids are released from oxidized minerals. (Johnson & Hallberg, 2011). Negative impacts to biodiversity occur over great distances sediment export from Madre de Dios in Peru degrades ecosystems along connecting rivers in Brazil(Asner *et al*., 2013) and leave only tolerant species behind (Li, Duan, Li, Kuang, Zeng & Shu, 2010). Landscape and region-wide impacts on biodiversity also emerge through indirect/secondary and cumulative pathways (Raiter, Possingham, Prober & Hobbs, 2014). Indirect impacts occur when mining facilitates leads to additional biodiversity loss. For example, mining associated infrastructure development can attract human populations causing new threats (Sonter, Herrera, Barrett, Galford, Moran & Soares, 2017) or exacerbate pre-existing threats, such as over-exploitation(e.g. hunting, fishing), invasive species and habitat loss for other land uses (Alamgir et al, 2017, Fischedick, 2014). Aggregate effects happen when numerous mines cause more biodiversity misfortune than the amount of individual mines. These cycles and ramifications for biodiversity have gotten little consideration in the writing. While biodiversity loss is a critical challenge to sustainable development with many species threatened with extinction, there is a growing awareness of how biodiversity supports human livelihoods (UNEP 2010b). 21% of freshwater species in mainland Africa are undermined with eradication, putting the vocations of millions of individuals in danger. Among areas in Africa with important concentrations of threatened species are the Upper Guinea forests of West Africa, the forests of western Cameroon and eastern Nigeria, the Albertine Rift of Central Africa, the Eastern Arc Mountains of the United Republic of Tanzania, and Madagascar (UNECA, 2013).

2.6 Forest Management Planning for Sustainable Tropical Forest Management

Implementing effective conservation strategies to mitigate the impacts of mining on forest management for that matter biodiversity requires understanding the distribution of threats. Mined materials (e.g., metals, construction materials, fossil fuels) are unevenly spread across Earth's terrestrial biomes and extraction poses unique threats to their biodiversity (Sonter, Ali & Watson, 2018). For instance, copper stores will in general happen in deserts and xeric shrub lands, nickel deposits are habitually mined in tropical and subtropical fields and savannahs, and lead deposits happen in boreal woodlands. In any case, co-event of mined materials and biodiversity doesn't generally convert into a danger; numerous different variables are likely affecting everything

Different mining methods pose different threats to biodiversity. Extracting subsurface alluvial gold deposits affects riparian ecosystems (Asner *et al*., 2013) and downstream ecosystems dependent on regional hydrology; whereas high-value thermal coal is often associated with prime agricultural land, high-quality soils, flat accessible terrains (Lechner, Baumgartl, Matthew & Glenn, 2016) and thus already highly threatened ecosystems. Various materials are additionally extricated utilizing various methods with differing ramifications for biodiversity. While stone, sand and rock mining moves most earth, the geochemistry of metal minerals and reagents used to mine and deal with them regularly cause more chemical secretions than production materials (Bridge, 2014). Differences also exist between industrial operations and small-scale artisanal mining (Asner *et al*., 2013); large operations can have greater potential for impact but also greater capacity to minimize damage.

Threats by mining differ among species and ecosystems. While positive relationships exist between mineral deposits and plant species richness (Murguia, Bringezu & Schaldach, 2016), protected areas (Duran, Rauch & Gaston, 2013) and intact areas of high conservation value (Miranda *et al*., 2014; Venter *et al*., 2016), the full consequences of mineral extraction are not well understood. Sometimes, mining forever eliminates whole ecosystems, especially where biota have co-advanced with mineral substrates (Erskine, Van der Ent & Fletcher, 2012). Such is the case in Brazil, where iron mining removes exceptionally diverse plant communities entirely (Jacobi, Carmo & Campos, 2011). In different cases, spatial occurrence among minerals and biodiversity may prompt less critical effects, in light of the fact that either extraction is infeasible, biodiversity is unaffected by mining, or mining causes less damage than alternative land uses (Sonter, Barretta, Moran & Soares-Filho, 2015). Little is known about threats in extreme environments, such as mountaintops (Wickham *et al*., 2013), karsts (Clements, Sodhi & Schilthuizen, 2014; Jaffe *et al*., 2016), marine systems (Boschen, Rowden, Clark, Pallentin & Gardner, 2016; Wedding *et al*., 2013) and Polar Regions (Chown, 2012; Trump, Kadenic & Linkov, 2018).

A forest management plan interpret public or territorial woods rules into a mindfully arranged and all around facilitated operational program for a woodland and for controlling ranger service exercises for a set time period through the application of prescriptions that specify targets, action and control arrangements (Boiral & Heras-Saizarbitoria, 2017). It is an indispensable part of a forest management system and should regulate protection, inventory, yield determination, harvesting, silviculture, monitoring and other forest operations (Sonter *et al.,* 2018). It should always provide firm guidance on the log yields which may be cut and also specify where and under what conditions and constraints the yield may be harvested (UNECA, 2013).

In addition, a forest management plan is required to provide continuity in managerial operations overtime, to formalize administrative arrangement and to provide a basis for monitoring forest activities. A key criterion for the sustainable management of tropical forest is the existence and effective implementation including monitoring of an approved management plan that has been prepared using up to date and accurate information (Boiral & Heras-Saizarbitoria, 2017). A forest management plan has the purpose not only of setting out approved management objectives and specified action, but equally communicating to people who are concerned with the implementation of a plan in a forest or a group of forest to which it applies (UNECA, 2013).

In sum, the literature throws more light on the impact that mining has on the environment, and the effect it also has on the forest ecosystem and the forest resources when carried out in forest reserves. The impact on the forest ecosystem will be considered in the study as the threats to forest management, Consequently the study is carried out to assess the threats that open cast mining practices in forest reserves has on forest management in the Tarkwa forest district.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

A detailed description of how the research was conducted has been given in this chapter. Issues considered under the methodology of the study were, the study area which covers the location and size, topography and drainage, climate, vegetation, mining and population structure. Research design, population of the study, sampling procedure, data collection instruments, type and sources of data, sample size and data analysis were also included in this chapter.

3.2 Study Area

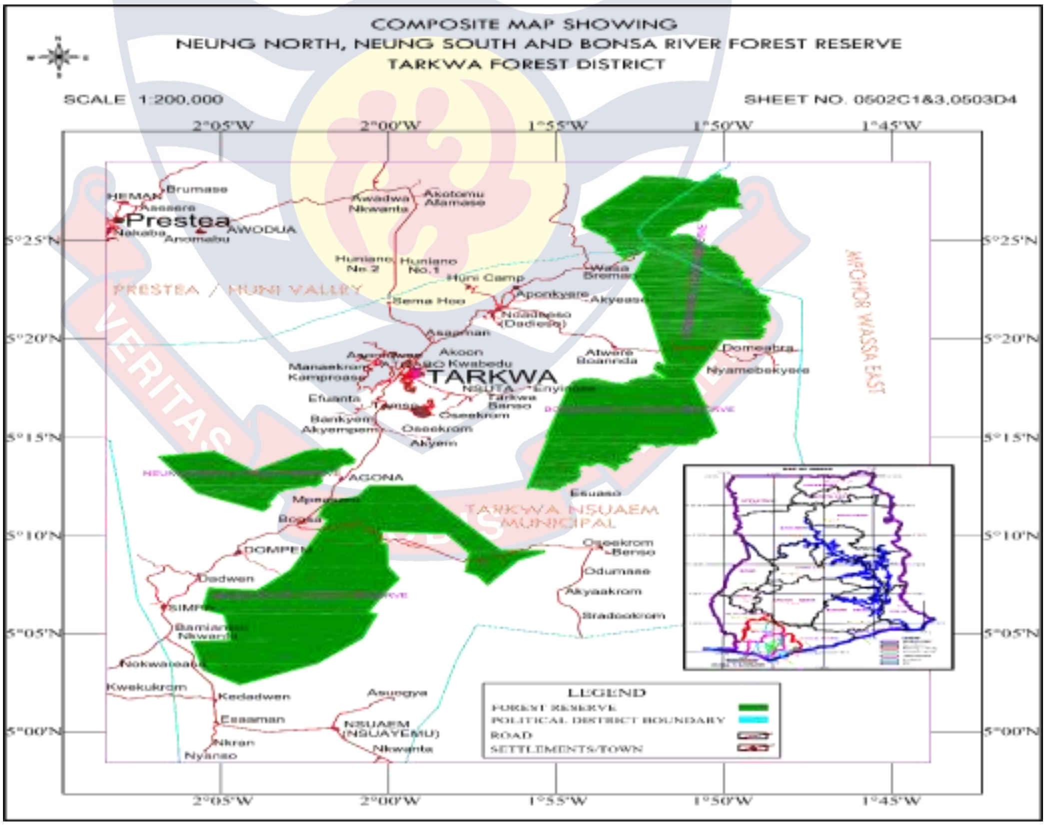

Figure 1: Map of Tarkwa Forest District

Source: Field Survey, August 2020

3.2.1 Location and size of study area

The study was carried out in the Tarkwa Forest District in the Western region of Ghana. In terms of forest activities, it is one of the seven districts and one of the oldest forest districts in the Western region. Tarkwa Forest District is located in the Tarkwa-Nsuaem Municipality created from the former Wassa West district under legislative Instrument (LI) 1886 in 2007. At the north, it shares boundary with Prestea Huni-Valley, Ahanta West at the south, and Mpohor- Wassa East at the east and Nzema East District at the west. The Tarkwa - Nsuaem Municipality has a total land area of 905.2 sq.km and the land rises from about 240 to 300 meters above sea level. It has 438 communities with Tarkwa as it capital.

3.2.2 Topography and drainage of study area

The Tarkwa-Nsuaem municipality is generally undulating with heights ranging from 122m-183m. Steep sided hills of heights reaching about 243.8m occur in the south east and North-west of the reserve. The main drainage is made up of many head waters of the Ben West river and its tributaries, which are Enifufu, Beni, Mpetijei, Pimikese, Anwiaso and Kwaklanhlu streams and rivers which flows into the Bonsa river, and serves as a source of water for the township and its environs.

3.2.3 Climate of study area

The Tarkwa-Nsuaem Municipality lies, within the south western equatorial climate zone with a double maximum rainfall regime. The municipality experiences the highest rainfall in Ghana with a mean annual rainfall of 1,500mm. Temperatures are uniformly high throughout the year with the hottest being 30^{o}c which is normally recorded in March. Relative humidity is high throughout the year, with the highest humidity experienced during the wet season, when it is 75-78 percent. Dry conditions are experienced in the municipality between November and February when the north east trade winds blow over the areas.

3.2.4 Vegetation of study area

The municipality falls within the rain forest belt with the vegetation basically wet evergreen forest type. The forest is made of trees with heights ranging between 15 to 40 meters and full of climbers and lianas which are able to reach into the upper canopy layer. Tarkwa-Nsuaem municipality can boast of reserves like Bonsa river reserve, Neung south and Neung north forest reserves.

The good state of the forest has contributed to the maintenance of rich biodiversity and a genetic hotspot for rare species of flora and fauna. Timber extraction associated with destructive logging practices, environmentally damaging illegal mining activities and poor farming practices have contributed to fast deforestation of the area.

3.2.5 Mining in study area

The Tarkwa-Nsuaem municipality could be considered as the first-place mining activities began in the country. The Wassa indigenes of Apinto were mining gold before the Europeans from Portugal and Britain arrived in the country between 1453 and 1622.

The minerals from deep pits and underground gold mines had been operating in Tarkwa and Bogoso sites before the Geological survey department was established in 1913.

The first mechanical dredge mining used in Ghana is at Awudua near Booho presently called Gambia. Many of the communities have huge mineral deposits of gold, manganese and bauxite which are economically viable. There are three major large scale mining companies like Gold Fields Ghana Ltd, Anglo Gold Ashanti and Ghana Manganese Company and a great number of small-scale mining outlets which give employment to an appreciable percentage of the population.

3.2.6 Population Structure of study area

Records from the statistical services 2010 population and housing census indicated that the Tarkwa -Nsuaem Municipality had a population of 90,477 about 3.8%of the western regional population. The sex distribution of the population reveals that there are more males (51.6%) than females (48.4%). The municipality is predominantly rural with 69.7% of its population residing in the rural areas. Details of the sex distribution is indicated in the table 1.

Table 1 Sex Distribution of the Population Structure of study area

Sex	Population	Percent (%)
Male	46,686	51.6
Female	43,791	48.4
Total	**90,477**	**100**

Source: Ghana Statistical Service, 2012

3.3 Research Design

Descriptive research design is used for the study. This is because, the researcher is solely interested in describing the situation under this study. This is achieved by gathering, analyzing and presenting the collected data and it allows the researcher to provide insights into the why and how of the research. This is also to help others to have a better understanding of the need of the research.

3.4 Population of the study

Agona, Bonsa and Bonsawere communities selected for the study has a target population size of 300 each, together with a target population of 100 Forest Services Division staff in the district for the study. This makes the total target population size of the study to be 1,000 individuals.

3.5 Sample Size

The decision for the selection of the sample size of the respondents was based on the population size of inhabitants in the selected communities.

The total sample size from the target population considered for the study is hundred (100) respondents. These included 30 respondents, each from Agona, and Bonsa communities, and 20 from Bonsawere community all within the Tarkwa- Nsuaem Municipality of the Western Region of Ghana. 20 respondents are also selected from the managerial and non-managerial staff from the Forest Services Division of the Forestry Commission in the Tarkwa forest district.

Table 2: Population Size

Community	Target Population size
Agona	300
Bonsa	300
Bonsawere	300
Forest Services Division	100
Total	**1,000**

Source: Field Survey, August 2020

Table 3: Sample size

Institution/Community	Number of Respondents	Percentage
Agona Community	30	30
Bonsa Community	30	30
Bonsawere Community	20	20
Forest Service Division	20	20
Total	**100**	**100**

Source: Field Survey, August 2020

3.6 Sampling Technique

The method employed for the study was simple random sampling. Simple random sampling was used to select the inhabitants from each of the three communities for the questionnaires.

80 inhabitants are selected from the three communities for the questionnaires. This was because they are very close to the forest reserve and therefore have a fair idea of whatever goes on in the forest reserve. 20 respondents are purposively selected from the Forest Services Division in the district because they are in charge of the forest reserves. In all 100 respondents were selected for the questionnaires. The views obtained from the 100 respondents representing the total sample are considered the views of the entire population.

3.7 Sources of Data

The sources of data for this study is from primary and secondary sources. The primary data is obtained from the field through various data collection techniques, including questionnaire survey, interviews, and field observation.

Secondary data is sourced from books, relevant articles, journals and magazines as well as relevant publications and researches conducted on the subject matter by individuals and institutions.

3.8 Data Collection Instruments

The data is collected from secondary and primary sources. Primary data is collected through the use of questionnaire. Primary data is obtained by administering questionnaires to respondents. The questionnaires focused on the main objectives of the study. The questionnaires consisted of both closed ended and open-ended questions. In addition, statements made by respondents that were found to be relevant to the study is collected and presented to support the research findings.

3.9 Data Collection Procedure

Data for the study are obtained from primary and secondary sources. Primary data are derived from administering of structured questionnaires to some chiefs, opinion leaders and community members in the selected forest fringe communities for their opinions on the study.

The Forestry Commission staff in the district are served with questionnaires to seek their views on the study. Field inspections are also carried out in the three forest reserves namely Neung south, Neung north and the Bonsa river forest reserves where the mining activities are taking place to have a fair view of the situation on the ground.

Structured questionnaires for the study are administered for a period of three months with the assistance of three forest range managers in charge of the affected forest reserves. Secondary data on the study are obtained from books, institutional manuals, conference reports, articles from researches about the study carried out on the internet and the study of offences reports on mining activities in the Tarkwa district.

3.10 Ethical Consideration

Participants are assured of anonymity, since the data is collected for academic purposes. They are assured that the information they give out will not be used as a form of punishment against them. The data collected will be put together in bulk and analyzed so that no individual will be identified by what they said or wrote.

3.11 Data Analysis

The collected data are analyzed using the Special Package for Social Sciences (SPSS) version 21.0 for computing and analyzing the questionnaires. For frequencies and percentages analyses, descriptive statistics is used to analyze the questionnaires. The qualitative data content is being analyzed and respondent are asked to clarify where necessary.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the findings of the study based on information gathered from the field. This chapter discusses the research results based on the research objectives and gives a summary of the survey results which are presented by tables.

4.2 Open Cast Mining Processes in the Forest Reserves

The study inquired from respondents the open cast mining processes that take place in the forest reserve before and after mining is carried out. The survey result shows that, all the 100 respondents which represent a 100% of the total sample size mentioned search for gold as the main activity carried out in the forest reserves before open cast mining is done. None of the respondents mentioned determination of the quantity of minerals in an area, exposure of mineral deposits for extraction, and restoration of land after mineral extraction as being carried out by the miners in the forest reserves. Some respondents verbally disclosed that:

"The people involved in open cast mining in the forest reserves do it illegally. In order to avoid arrest, they do not go through all the mining processes. As a result, immediately they detect gold in an area, they quickly extract and move to another area".

4.3 Open cast Mining Activities in the Forest Reserve

Majority of 95 respondents representing 95% of the total sample size revealed that, ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of mineral ores are the activities that are carried out in the forest reserves under the open cast mining processes, while 3 people which represent 3% of the total sample size said, the activities that are carried out in the forest reserves under open cast mining processes include only digging of tunnels, trenches and pits with a minority of 2 respondents constituting 2% also stating ground fixing of gold detector machines, digging of tunnels, trenches and pits, and extraction of mineral ores, as the activities that are carried out under the open cast mining operations in the forest reserves. From the results majority of the respondents mentioned ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of ores as the activities carried out in the forest reserves under open cast mining activities. There is therefore the indication that the activities carried out in the forest reserves under open cast mining have effects on the forest resources.

Table 4 depicts the activities that are carried out in the forest reserves under the open cast mining processes.

Table 4: Open cast Mining Activities in the Forest Reserve

Open cast mining activities	Number of respondents	Percentages (%)
Digging of tunnels, trenches and pits	3	3
Ground fixing of gold detector machines. Digging of tunnels, trenches and pits. Blasting and cutting of rocks. Construction of sheds and wooden structures. Extraction of mineral ores. Washing of ores.	95	95
Ground fixing of gold detector machines. Digging of tunnels, trenches and pits. Extraction of mineral ores.	2	2
Total	**100**	**100**

Source: Field Survey, August 2020

4.4 Does Open Cast Mining Activities have effect on the Forest Reserve Condition?

Table 5 represents the assertion of respondents about the open cast mining activities. It was inquired from respondents whether they agree or not that, the open cast mining activities carried out in the forest reserves have effect on the condition of the forest reserves. The study revealed that majority of the respondents constituting 61% of the total sample size strongly agreed that the open cast mining activities have effects on the condition of the forest reserves while 36 respondents representing 36% of the total sample size agreed that open cast mining have effects on the forest reserve with 3 respondents representing a minority of 3% strongly disagreeing that the opening cast mining activities have effects on the condition of the forest reserves.

In all, a total of 97 respondents constituting 97% of the total sample size agreed that, the open cast mining activities carried out in the forest reserves have an effect on the condition of the forest reserves. Therefore, the results confirm the statement by Kumi- Boateng *et al*., (2012) that mining cause's massive damage to landscapes, flora, and fauna through the clearing of top soil to make room for surface mining.

Table 5: Open Cast Mining Activities have effect on Forest Reserve

Open cast mining activities have effects on forest reserve	Frequency	Percentage (%)
Strongly Agree	61	61
Agree	36	36
Strongly Disagree	3	3
Total	**100**	**100**

Source: Field Survey, August 2020

4.5 Open cast mining activities that poses threat to the Forest Reserves

Table 6 represents open cast mining activities causing serious threats to the forest reserves. The respondents were asked to indicate the open cast mining activities that caused serious threats to the forest reserves. The results revealed that, 77 of the respondents representing 77% of the total sample size, stated that ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of ores were the activities that caused serious threats to the forest reserves, 9 respondents representing 9% also mentioned, digging of tunnels, trenches and pits as the only activities that caused serious threats to the forest reserves while 8 respondents representing 8% indicated only ground fixing of gold detector machines as the activity that caused serious threats to the forest reserves with a minority of 6 respondents representing 6% also stating blasting and cutting of rocks as the only activities that caused serious threat to the forest reserves.

From the study results, majority of the respondents mentioned all the open cast mining activities carried out in the forest reserves to cause serious threats to the forest reserves. Consequently, this revealed that open cast mining activities carried out in the forest reserves cause serious threat to the forest reserves. This confirms what Kumi-Boateng *et al*., (2012) observed, that mining activity impacts negatively on the environment and the severity of the impact depends on the mining methods used.

Table 6: Open mining activities that poses threat to the Forest Reserves

Description	**Frequency**	**Percentage (%)**
Ground fixing of gold detector machines	8	8
Digging of tunnels, trenches and pits	9	9
Blasting and cutting of rocks	6	6

Ground fixing of gold detector

machines

Blasting and cutting of rocks

Construction of sheds and wooden structures	77	77
Extraction of mineral ores		
Washing of ores		
Total	**100**	**100**

Source: Field Survey, August 2020

4.6 Effects of Open Cast Mining Activities on Forest Reserve Condition

Table 7 indicates the results of the effect of open cast mining activities on the condition of the forest reserves. From the study, a majority of 83 respondents which represents 83% of the total sample size stated that, the effects that open cast mining activities have on the condition of the forest reserve includes destruction of trees and vegetative cover, removal of topsoil and soil erosion, contamination and drying of water bodies, creation of pits, tunnels and trenches in the forest reserve, destruction of habitats, loss of animals and soil microorganisms, soil compaction and loss of soil fertility, 14 of the respondents representing 14% of the total sample size also disclosed that the activities of open cast mining cause destruction of trees and vegetative cover whereas a minority of 3 respondents which represents 3% of the total sample size revealed that open cast mining activities only leads to creation of pits, tunnels and trenches in the forest reserve. This corroborates what Lambin et al, (2018) stated that mining can have extensive impact on biodiversity. Sonter, Barrett, Moran & Soares, (2015) also affirms that mining causes extensive habitat loss.

Table 7: Effects of Open cast mining activities on Forest Reserve Condition

Effect of open cast mining	**Number of respondents**	**Percentages (%)**
Destruction of trees and vegetative cover	14	14
Creation of pits, tunnels and trenches in the Forest Reserve	3	3
Destruction of trees and vegetative cover Removal of topsoil and soil erosion Contamination and drying of water bodies Creation of pits, tunnels and trenches in the Forest Reserve Destruction of habitats, threats to animals and soil microorganism Soil compaction and loss of soil fertility	83	83
Total	**100**	**100**

Source: Field Survey, August 2009

4.7 Respondents awareness of the impact of open cast mining on forest management

Table 8 shows the response to the awareness of open cast mining activity having effects on forest management. From the study results, all respondents agreed that they are very much aware that open cast mining activities have effects on management of the forest reserves in the district. Thus, a majority of 63 respondents representing 63% of the total sample size affirm their awareness about the effects that open cast mining have on forest management while, a minority of 37 respondents representing 37% of the total sample size are strongly aware of the effects of open cast mining on forest management. The result proves respondents' awareness of the effects of open cast mining on the management of the forest resources. A male respondent reported that "*I have been mining in this forest reserve for quite a long time and I am strongly aware of the consequences of my activity especially on river bodies*.

Table 8: Respondents awareness of the impact of open cast mining on Forest management

Awareness of the impact of open cast mining on forest management	Frequency	Percent (%)
Strongly Aware	37	37
Aware	63	63
Total	**100**	**100**

Source: Field Survey, August 2020

4.8 Impact of Open Cast Mining Activities on Forest Management

Table 9 shows responses to how mining activities affect forest management. From the table, a majority of 47 respondents representing 47% of the total sample size stated all the reasons attributed to affecting forest management from open cast mining activities, 30 respondents representing 30% of the sample size revealed that management of the forest becomes difficult if the area is degraded,

19 respondents constituting 19% of the total sample size mentioned that, it is difficult to reclaim mined areas since it involves huge money while 4 respondents representing 4% of the sample size disclosed that mining activities affect forest management practices in the district by making working in the forest reserve very difficult, since one may unknowingly

fell into a pit and die. A majority of the respondents mentioned all the factors attributed to affecting forest management from opening cast mining operations. There is therefore the indication that opening cast mining in forest reserves is affecting management of the forest resources with a confirmation of what Osafo, (2010) said that forest reserves are being degraded or in worse conditions especially in areas where deforestation or degradation has occurred.

Table 9: Impact of Open Cast Mining Activities on Forest Management

Impact of open cast mining activities on forest management	**Frequency**	**Percentage (%)**
Managing the forest reserves becomes difficult if the area is degraded	30	30
It makes working in the forest reserve very difficult since one may unknowingly fell into a pit and die	4	4
It is difficult to reclaim minded areas since it involves huge sums of money	19	19
Managing the forest reserves becomes difficult if the area is degraded It is difficult to reclaim mined areas since it involves huge money It makes working in the forest reserve very difficult since one may unknowingly fell into a pit and die Destruction of trees leads to forest encroachment by chainsaw operators and loss of revenue	47	47
Total	**100**	**100**

Source: Field Survey, August 2020

4.9 The awareness of mitigation measures by Forestry Commission

Table 10 represent responses to the awareness of the mitigation measures put in place by the management of Forestry Commission in the district to control open cast mining activities in the forest reserves. Majority of 74 respondents constituting 74% of the total sample size are strongly aware that there are measures put in place to control open cast mining activities in the forest reserves whilst, 16 respondents representing 16% of the total sample size are aware of these measures. This indicates that almost all the respondents (90%) are aware of the mitigation measures put in place by management to control open cast mining activities in the forest reserves. Minority of 10 respondents constituting 10% of the total sample size are unaware of these mitigation measures.

Table 10: Respondents Awareness of Mitigation Measures by Forestry Commission

Awareness of mitigation measures	Frequency	Percentage (%)
Strongly Aware	74	74
Aware	16	16
Strongly Not Aware	3	3
Not Aware	7	7
Total	**100**	**100**

Source: Field Survey, August 2020

4.10 Mitigation measures against the open cast mining method

Table 11 shows the responses to the mitigative measures put in place by management to help control open cast mining activities in the forest reserves. From the survey, 16 respondents representing 16% stated patrolling and inspections in the forest reserves as the mitigation measures put in place to control open cast mining, 14 respondents also mentioned sensitization in the forest fringe communities as the mitigation measures put in place to control open cast mining activities in the forest reserves, while 9 respondents forming 9% of the total sample size indicated occasional arrest of miners in the forest reserves by the regional rapid response team and the military as the mitigative measures put in place to control open cast mining in the forest reserves. However, majority of the respondents representing 61% agreed to all the options mentioned and believe they will all curb in mitigating the impact of open cast mining in the forest reserve. A respondent disclosed that:

"Continuous *education in the communities on the dangers associated with mining in this precious forest reserves will be better in protecting our river bodies from pollution and drying up*"

Table 11: Mitigation measures against open cast mining method

Mitigation measures against open cast mining method	**Frequency**	**Percentage (%)**
Patrolling and inspections are carried out in the forest reserve	16	16
Occasional arrest of miners in the forest reserve by the regional rapid response team and the Military	9	9
Sensitization in the forest fringe communities about the effects of mining in the forest reserves	14	14

Patrolling and inspections are carried out in the

forest reserve.		
Occasional arrest of miners in the forest reserve by the regional rapid response team and the military. Sensitization in the forest fringe communities about the effects of mining in the forest reserves.	61	61
Total	**100**	**100**

Source: Field Survey, August 2020

4.11 Significance of Protecting the Forest Reserve

Table 12 shows responses from respondents on the need to protect forest reserves from open cast mining practices in the forest reserves. 91 respondents representing a majority of 91% of the total sample size made it known that, the forest reserves should be protected to enable them continue to enjoy its direct and indirect benefits, must be protected for current and future generations, to generate revenue from the forest resources, prevent loss of biodiversity, prevent pollution and drying up of water bodies and prevent loss of soil and soil fertility,7 of the respondents said the forest reserves should be protected to enable us continue to enjoy the direct and indirect benefits we get while 2 of the respondents representing 2% of the sample size said the forest reserves must be protected for current and future generations. This finding reveals how respondents are passionate about the need for the protection of the forest reserve. The need to protect forest reserves and the suggestions from respondents is in accordance with the assertion by UNDP, (2010) that forest fulfils environmental, social, economic and cultural roles in many countries. A respondent further stated that:

"*I personally came to meet this forest here since childhood, I liked it very much but its state has changed gradually, and even when I try explaining to the young ones what I enjoyed from this forest reserve, they seem not to believe me......*"

Table 12: Significance of Protecting the Forest Reserve

Significance of protecting the forest reserve	**Frequency**	**Percentage (%)**
The forest should be protected to enable us continue to enjoy the direct and indirect benefits we get. Forest reserves must be protected for current and future generations. To generate revenue from the forest resources. To prevent loss of biodiversity. To prevent pollution, blockage and drying up of water bodies. To prevent loss of soil and soil fertility.	91	91
The forest should be protected to enable us continue to enjoy the direct and indirect benefits we get.	7	7
Forest reserves must be protected for current and future generations.	2	2
Total	**100**	**100**

Source: Field Survey, August 2020

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter presents the summary, conclusions and recommendations of the study. The chapter provides information on the summary of the findings, conclusion and also recommendations.

5.2 Summary

The importance of forest reserves is being undermine through various forms of degradation which are threats to forest resources and management of the resources. Thus, the study examined threats that mining practices have on forest reserve management in the Tarkwa forest District in the Western region of Ghana. The objectives of the study are to examine the open cast mining processes use in the forest reserves, the effects it has in the forest reserves in which it is carried out and the measures put in place to control this mining practices. Descriptive research design was used for the study which involves both qualitative and quantitative methods. Quantitative surveys were employed and descriptive statistics are used to determine frequencies and percentages using the Special Package for Social Sciences (SPSS) version 21.0.

Quantitatively, the responses from respondents were determined in percentages based on the number of respondents and it is revealed from the study that, search for gold is the main activity carried out in the forest reserves before open cast mining is done. Respondents emphasized that, after searching for gold, and mining no other processes are carried out in the forest reserve. Majority of the total sample respondents size revealed that, ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of mineral ores are the activities that are carried out in the forest reserves under the open cast mining processes. Majority of the respondents strongly agreed that, the open cast mining activities have effects on the condition of the forest reserves. Also, majority of respondents stated that ground fixing of gold detector machines, digging of tunnels, trenches and pits, blasting and cutting of rocks, construction of sheds and wooden structures, extraction of mineral ores, washing of ores were the activities that caused serious threats to the forest reserves. Majority of the respondents affirm their awareness about the effects that open cast mining has on forest management, also majority of the respondents are strongly aware that there are measures put in place to control open cast mining activities in the forest reserves. Findings from the study also reveals how respondents are passionate about the need for the protection of the forest reserve.

5.3 Conclusion

Forest reserves provides environmental, economic, social and cultural benefits that are essential for human survival. Consequently, protecting and managing the forest will help protect its resources and it will maintain or enhance their benefits to current and future generations. Hence, the study sought to examine threats that open cast mining practices have on forest management in the Tarkwa forest district in the Western region of Ghana. It was disclosed that, the search for gold and extraction of the mineral ores are the two open cast processes going on in the forest reserves.

The study found out that, ground fixing of gold detector machines, digging of tunnels trenches and pit, blasting and cutting of rocks, construction of shelves and wooden structures and the extraction and washing of mineral ores are the activities carried out in the forest reserves under the two open cast mining processes. These activities negatively affect the condition of the forest reserves through the destruction of trees and vegetative cover, creation of pits, tunnels and trenches, removal of top soil, soil compaction with resultant loss of soil fertility and soil erosion, loss of animals and soil micro-organisms, destruction of habitats, pollution and drying up of water bodies.

Furthermore, the respondents are aware that open cast mining activities have negative effects on the forest reserve and they are able to identify the of effects it has on the forest management which are managing the forest reserves becomes difficult if the area is degraded, and working in the forest reserve is also difficult since one may unknowingly fell into a pit and die. Destruction of trees through mining activities leads to forest encroachment by chainsaw operators and loss of revenue. Therefore making it difficult to reclaim mined areas since it involves money.

However, they are very much aware about some mitigation measures put in place by the forestry commission to help mitigate this crisis but they still continue to operate in the forest reserve since most of them depend on it for revenue to help them survive.

5.4 Recommendations

Based on the conclusions of the study, the following recommendations are made and together with the existing mitigation measures, the threats will gradually be mitigated:

Firstly, the Forestry Commission should encouraged the Regional Rapid Response Team and the Military to work effectively when patrolling the forest reserve. They should be supplied with modern equipment to work with and there should be luxurious incentives which will motivate the rapid response team and the military to effectively carry out their duty.

Secondly, the Chief of the community, the Forestry Commission and other stakeholders should come together to sensitize the populace to carry out the mining activities in a less destructive manner. Educating and training them about how to do mining properly without damaging the forest reserve and also making them aware about the future of the forest if such practices are not done right. These can be done through the local FM stations and also by engaging the miners in the community.

Thirdly, Collaborative forest management should be encouraged in the communities. This is to make them aware that, the forest is for them and the benefits they keep getting from the forest will seize if the threats continue to increase due to the effects the mining activities will have on the condition of the forest reserve in the future. This will make their future generation suffer the consequences of their present action. This will therefore be a source of motivation for them to abide by the rules and regulations put in place to curb these threats.

Lastly, Ministry of Local Government and Rural Development should create lucrative jobs in the rural areas to engage the youth in order to prevent them from solely indulging in illegal mining activities. When there are numerous work opportunities and job offers in the community, there will be diverse ways of earning income for survival. This will lift the pressure on the forest reserve where open cast mining solely takes place in the community.

REFERENCES

Akabzaa, T & Dramani, A. (2010). *The impact of mining sector investment: A study of the Tarkwa mining Region. A Draft Report*, Structural Adjustment Participatory Review International Network (SAPRIN).

Alamgir, M., Campbell, M.J., Sloan, S., Goosem, M., Clements, G.R., Mahmoud, M.I & Laurance, W.F. (2017). Economic, socio-political and environmental risks of road development in the tropics. *Current. Biology. 27*, R1130–R1140.

Ambali, E.C. (2010). *Mining in Africa.* Retrieved 21st January 2020 http://www.ippmedia.com/ipp/guardian/2005/12/31/56886.html

Amponsah-Tawiah, K., Dartey –Baah (2011).*The mining Industry in Ghana, A Blessing or a curse,* University of Ghana Business School, Department of Organization, Human Resources Management, Legon. Retrieved 6th August 2019 https:// www.ijbssnet.com

Asner, G.P., Llactayo, W., Tupayachi, R & Luna, E.R. (2013). Elevated rates of gold mining in the Amazon revealed through high-resolution monitoring. *Proc. National Academy of. Science USA 110*, 18 454–18 459.

Aubynn, E. A. (2012). *The community perception on mining; Experience from western Ghana.* Master‘s Thesis. Department of Atmospheric Science; University of Alberta Canada, Department of General and African Studies.

Balasubramanian, A. (2017). *An overview of mining methods, Centre for Advanced studies in Earth science,* University of Mysore. Retrieved 10th March 2017. https://www.researchgate.net/publication/314502989

Boadi, S. Ayine Nsor, C. Osei Owusu, A. Acquah, E. (2016). An analysis of illegal mining on the Offin Shelter belt forest reserve; Implications of community livelihood.

Boateng, A. (2011). Some emerging concerns on surface gold mining in *Ghana*. *Environmental Protection Agency Newsletter*. *EPA-GHANA, 1(7)*: 5 – 8.

Boiral, O & Heras-Saizarbitoria, I. (2017). Corporate commitment to biodiversity in mining and forestry: identifying drivers from GRI reports. J. *Clean Prod. 162*, 153–161.

Boschen, R.E., Rowden, A.A., Clark, M.R., Pallentin, A & Gardner, J.P.A. (2016). Seafloor massive sulphide deposits support unique mega fauna assemblages: implications for seabed mining and conservation. *Mar. Environmental Resources 115*, 78–88.

Bridge, G. (2004) Contested terrain: mining and the environment. *Annual Review Environmental Resource* 29,205–259

CBD Secretariat (2010). Global Biodiversity Outlook 3. *Convention of Biological Diversity Montréal*, 94.

Chown, S.L. (2012). Antarctic marine biodiversity and deep-sea hydrothermal vents. Plos Biology 10, e1001232. Clements, R., Sodhi, N.S & Schilthuizen, M. (2014). Limestone karsts of Southeast Asia: imperiled arks of biodiversity. *Bioscience 56*, 733–742.

De Groot, R.S., Alkemade, R., Braat, L., Hein, L & Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complex. 7,* 260–272.

Duran, A.P., Rauch, J & Gaston, K.J. (2013). Global spatial coincidence between protected areas and metal mining activities. *Biological Conservation 160*, 272–278.

Ellison, D., Morris, C.E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., Gutierrez, V., Noordwijk, M.V., Creed, I.F., Pokorny, J. *et. al.*, (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change. 43*, 51–61.

Erskine, P., Van der Ent, A & Fletcher, A. (2012). Sustaining metal-loving plants in mining regions. *Science 337*, 1172–1173.

FAO (2010). Global forest resources assessment 2010 – *Main report. FAO Forestry Paper 163.* Rome, Italy. Retrieved 2nd February 2020 www.fao.org/forestry/fra/fra2010/en/

FAO (2012). *The state of the world's forests 2012 (SOFO 2012)* – Executive Summary. Retrieved 2nd February 2020 http://foris.fao.org/static/sofo/SOFO2012_executiveSummary.pdf

FAO (2020).*Food and Agriculture of the United Nations*. Retrieved 2nd February 2020 www.fao.org/forestry /sfm/85084/en/

Fischedick, M.J et al. (2014). *Climate change: industry. In Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change (Eds. O. Edenhofer et al.).* Cambridge, UK: Cambridge University Press.

Ganzhorn, J.U., Goodman, S.M & Vincelette, M. (2011). *Biodiversity, ecology and conservation of littoral ecosystems in South eastern Madagascar (Ed. A. Alonso).* Washington, DC: Smithsonian Institution.

Ghana Forest Planation Strategy (2016-2040) 11, 32, 64

Ghana Mineral Commission, (2010): *Gold deposits of Ghana*

Gobeze, T., Bekele, M., Lemenih, M & Kassa, H. (2011). Participatory forestry management and its impacts on livelihoods and forest status: the case of Bonga forest in Ethiopia. *International Forestry Review, 11(3)*: 346–358.

Goldfields. (2003). *Goldfields annual report Q3.* Retrieved 2nd February 2020 from www.goldfields.org

Gondo, P.C. (2011). Financing of sustainable forest management in Africa: An overview of the current situation and experiences. Southern Alliance for Indigenous Resources (SAFIRE), Harare.

Hamis, P. (2013). *A dissertation submitted in partial fulfilment requirements for the degree of Master of Science in management of natural resources for sustainable agriculture of Sokoine University of Agriculture, Mogoro*, Tanzania. Retrieved 28th December 2019

Hirons, M. (2013). Mining in Ghana's forests: Cross-sectoral linkages and the prospects for REDD. *International Development Planning Review.35.* 283-302. Retrieved 27th December 2019.

Howard L. Hartman, Jan M. Mutmansky. (2002). Introduction to mining engineering.

Jacobi, C.M., do Carmo, F.F & de Campos, I.C. (2011). Soaring extinction threats to endemic plants in Brazilian metal-rich regions. *Ambio 40*, 540–543.

Jacobi, C.M., do Carmo, F.F., Vincent, R.C & Stehmann, J.R. (2010). Plant communities on ironstone outcrops: a diverse and endangered Brazilian ecosystem. *Biodiversity Conservation 16*, 2185–2200.

Jaffe, R., Prous, X., Zampaulo, R., Giannini, T.C., Imperatriz-Fonseca, V.L., Maurity, C., Oliveira, G, Brandi, I.V & Siqueira, J.O. (2016). Reconciling mining with the conservation of cave biodiversity: a quantitative baseline to help establish conservation priorities. *PLOS ONE 11*, 16.

Johnson, D.B & Hallberg, K.B. (2011). Acid mine drainage remediation options: a review. *Science Total Environmental 338*, 3–14.

Kaczan, D., Swallow, B.M & Adamowicz, W.L. (2013). Designing a payments for ecosystem services (PES) program to reduce deforestation in Tanzania: An assessment of payment approaches. *Ecology Economics. 95*, 20–3

Kumi–Boateng B. Mireku Gyimah D. Duker A.A., (2012).A Spatio-Temporal based estimation of vegetation changes in the Tarkwa mining area. *Research Journal of Environmental and Earth science 4(3):*215-229, 2012. Maxwell Scientific Organization 2012. Retrieved 10th August 2019.

Lahiri-Dutt, K. (2013). May God give us chaos, so that we may plunder': *A critique of resource curse 'and conflict theory*. Retrieved 10th March 2020 from http://www.highbeam.com/doc/1G1-158526569.html

Lambin, E.F *et. al.*, (2018). The role of supply-chain initiatives in reducing deforestation. *National Climate Change 8*, 109–116.

Lawson, E.T & Bentil, G (2013): Shifting sands: Changes in community perceptions of mining in Ghana: *Environ Dev Sustain*.

Lechner, A.M, Baumgartl, T., Matthew, P & Glenn, V. (2016). The impact of underground longwall mining on prime agricultural land: a review and research agenda. *Land Degradation Development*. *27*, 1650–1663.

Li, J.T., Duan, H.N., Li, S.P., Kuang, J.L., Zeng, Y & Shu, W.S. (2010). Cadmium pollution triggers a positive biodiversity-productivity relationship: evidence from a laboratory microcosm experiment. *Applied Ecology 47*, 890–898.

Malm, O. (2010). Gold mining as a source of mercury exposure in the Brazilian Amazon. *Environmental Resources*. *77*, 73–78.

Manual of Procedure (MOP), Forest Resources Management Planning in the High Forest Zone (HFZ), section B-Operational Planning Table OP1 Forest Reserve Operational Planning, summary of main activities and targets.

Manual of Procedure (MOP), Forest Resources Management Planning in the High Forest Zone (HFZ), section A-Strategic Planning. Instruction sheet.

Manual of Procedure (MOP), Forest Resources Management Planning in the High Forest Zone (HFZ), section C-Sustainable Timber Production on reserve.

McAllister, M. L. and Fitzpatrick, P. J. 2010. Canadian mineral resource development: A sustainable enterprise? In Resource and environmental management in Canada: Addressing conflict and uncertainty ed. B. Mitchell. Mills, Ontario: Oxford University Press.

Mensah, A.K., Mahiri, I.O., Owusu, O., Okoree, D.M, Wireko, I., Kissi, E.A. (2015). Environmental Impacts of mining: A study of mining communities in Ghana. *Applied Ecology and Environmental sciences. 3.* 81-94. Retrieved 28th August 2019 from www.sciepub.com/portal/downloads

Minerals Commission (2000) *Minerals Commission of Ghana Website*. www.ghanamincom.gsf.fi

Mines & Communities. (2017). Ghana: *Campaign to stop the violence in mining.* Retrieved 26th March 2020 from http://www.mines andcommunities.org/article.phpa

Miranda, M., Burris, P., Bingcang, J.F., Shearman, P., Briones, J.O., La Vina, A & Menard, S. (2014). *Mining and critical ecosystems: mapping the risks.* Washington, DC: World Resources Institute.

Moran, D., Petersone, M & Verones, F. (2016). *On the suitability of input output analysis for calculating product-specific biodiversity footprints.* Ecological Indication. 60,192–201.

Murguia, D.I., Bringezu, S & Schaldach, R. (2016). Global direct pressures on biodiversity by large-scale metal mining: spatial distribution and implications for conservation. *J. Applied Environmental Management 180*, 409–420.

Osafo, Y. (2010). *Reducing emissions from tropical forest deforestation: Applying compensated reduction in Ghana. In: Tropical Deforestation* *and Climate Change*. (P. Moutinho and S. Schwartzman, Eds). – Pará, Brazil, IPAM; Washington D.C., USA, Environmental Defence.

Owusu. E.H., Ofori, B.Y. Attuquafio, D. (2017). *The Secondary impact of mining on primates and other medium to large mammals in forest reserves in south western Ghana*. Retrieved 12th November 2019 from http: //www vier.com/locate/exis.

Raiter, K.G., Possingham, H.P., Prober, S.M & Hobbs, R.J. (2014). Under the radar: mitigating enigmatic ecological impacts. *Trends Ecology Evolution. 29*, 635–644.

Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., Dasgupta, P., Dietz, T., Duraiappah, A.K., Hassan, R.; *et. al*., (2013). *Ecosystems and human well-being: Synthesis;* Millenium Ecosystem Assessment; Island Press: Washington, DC, USA, 2013.

Revised Timber Yield Regulation (2020). Resource Support Centre, Forestry Commission, Kumasi.

Sandlos, J. and Keeling, A. 2013. Zombie Mines and the (Over) burden of History. *The Solutions Journal*, 4(3).

Scheffers, B.R *et al.* (2016). The broad footprint of climate change from genes to biomes to people. *Science* 354,

Scullion, J.J., Vogt, K.A., Sienkiewicz, A., Gmur, S.J & Trujillo, C. (2014). Assessing the influence of land cover change and conflicting land-use authorizations on ecosystem conversion on the forest frontier of Madre de Dios, Peru. *Biological Conserv*ation 2014, 171, 247–258.

Serfor-Armah, Y., Nyarko, B.J., Dampare, S.B & Adomako, D. (2006). Levels of arsenic and antimony in water and sediment from Prestea, a gold mining town in Ghana and its environs. *Water, Air, & Soil Pollution 175*(1): 181-192.

Singh, N., Koku, J.E & Balfors, B. (2015). Resolving water conflicts in mining areas of Ghana through public participation a communication perspective. *Journal of creative communications 2*(3): 361-382.

Soares-Filho, B., Moutinho, P., Nepstad, D., Anderson, A., Rodrigues, H., Garcia, R., Dietzsch, L., Merry, F., Bowman, M., Hissa, L.; *et. Al*,. (2010). *Role of Brazilian Amazon protected areas in climate change mitigation.* Proc. National Academy of Science, USA 2010, 107, 10821–10826.

Sonter, L.J., Ali, S.H & Watson, J.E.M. (2018). Mining and biodiversity: key issues and research needs in conservation science. *Proc. R. Soc. B* 285.

Sonter, L.J., Barrett, D.J., Moran, C.J & Soares, B.S. (2015). Carbon emissions due to deforestation for the production of charcoal used in Brazil's steel industry. *National. Climate Change* 5, 359–363.

Sonter, L.J., Barretta, D.J., Moran, C.J & Soares-Filho, B.S. (2015). A land system science meta-analysis suggests we underestimate intensive land uses in land use change dynamics. *Applied Land Use Science. 10,* 191–204.

Sonter, L.J., Herrera, D., Barrett, D.J., Galford, G.L., Moran, C.J & Soares, B.S. (2017). Mining drives extensive deforestation in the Brazilian Amazon. *National Community 8*, 1013.

Trump, B.D., Kadenic, M & Linkov, I. (2018). A sustainable arctic: making hard decisions. *Arctic. Antarctic. Alpine Resources. 50.*

UNEP (2010). *State of biodiversity in Africa*. UNEP, Nairobi, Retrieved from http://www.cbd.int/iyb/doc/celebrations/iyb-egyptstate-of-biodiversity-in-africa.pdf

UNEP. (2011). Global environment outlook (GEO4). *Environment for development.* Nairobi: United Nations Environment Programme.

United Nations Economic Commission for Africa (UNECA). (2013). *Managing Africa's natural resource base for sustainable growth and development.* Sustainable Development Report on Africa IV, Addis Ababa, Ethiopia.

Veiga, M. M., Scoble, M. & McAllister, M. L. (2011). *Mining with communities.* Natural Resources Forum 25. Retrieved from http://www.unr.edu/mines/mlc/communities/nov14flyer.pdf

Venter, O *et. al.*, (2016). *Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation*. National Community 7, 12558.

Vuohelainen, A.J., Coad, L., Marthews, T.R., Malhi, Y & Killeen, T.J. (2012). *The effectiveness of contrasting protected areas in preventing deforestation in Madre de Dios, Peru.* Environmental. Management. 2012, 50, 645–663.

Wedding, L.M., Friedlander, A.M., Kittinger, J.N., Watling, L., Gaines, S.D., Bennett, M., Hardy, S.M & Smith, C.R. (2013). From principles to practice: a spatial approach to systematic conservation planning in the deep sea. *Proc. R. Soc. B* 280.

Wickham, J et al. (2013). The overlooked terrestrial impacts of mountaintop mining. *Bioscience 63,* 335–348.

Worrall, R., Neil, D., Brereton, D., and Mulligan, D. 2009. Towards a sustainability criteria and; indicators framework for legacy mine land. *Journal of Cleaner Production, 17*(16): 1426-34.

APPENDIX I

QUESTIONNAIRE

PRESBYTERIAN UNIVERSITY COLLEGE, GHANA

FACULTY OF DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

Dear Respondent,

I am a student of PUCG. I am carrying out a study on "threats to forest reserve management from mining practices in Tarkwa forest District of Ghana: I would be grateful if you could kindly provide me with answers to the following questions. The information provided would solely be used for academic purposes and your anonymity is assured. Thank you very much for agreeing to take part in this questionnaire.

The main objective of the study is to assess threats to forest reserve management from mining practices in the Tarkwa Forest District.

My Specific Objectives are:

1. To examine the open cast mining activities used in the forest reserves.
2. To assess the effects of the open cast mining activities on the condition of the forest reserves
3. To assess the mitigative measures put in place by the Forestry Commission to control mining activities in the forest reserve

Please tick where appropriate

SECTION A: TO EXAMINE THE OPEN CAST MINING ACTIVTIES IN THE FOREST RESERVES

1. Which of the following open cast mining processes take place in the forest reserve before m i n i n g is carried out?

a) Search for gold [ ] b) Determination of the quantity of minerals in area [ ]

c) Exposure o f mineral deposit for extraction [ ] d) Extraction of mineral deposit from the earth [ ]

e) Restoration of land after mineral extraction [ ]

2. Which of the following open cast mining processes take place in the forest reserve after mining is carried out?

a) Search for gold [ ]b) Determination of quantity of minerals in an area [ ]

c) Exposure of mineral deposit for extraction [ ] d) Extraction of mineral deposit from the earth [ ] e) Restoration of land after mineral extraction [ ]

3. Which of the following activities are carried out in the forest reserves under the open cast mining processes mentioned in Q2?

a) Ground fixing of gold detector machines [ ] b) Digging of tunnels, trenches and pits [ ]

c) Blasting and cutting of rocks [ ] d) Construction of sheds and wooden structures [ ] e) Extraction of mineral ores [ ] f) Washing of ores [ ] g) Use of dredger machines [ ]

h) Replacement of top soil and planting of trees [ ]

SECTION B: TO ASSESS THE EFFECTS OF OPEN CAST MINING ACTIVITIES ON THE CONDITION OF THE FOREST RESERVE.

Please Tick X against the answer which applies to you

4. Do you agree that the open cast mining activities mentioned above have effect on the condition of the forest reserves?

a) Strongly agree [ ] b) Strongly Disagree [ ] c) Agree [ ]e) Disagree [ ]

5. Which of the following open cast mining activities have effects on the forest reserves?

a) Ground fixing of gold detector machines [ ]b) Digging of tunnels, trenches and pits [ ]

c) Blasting and cutting of rocks [ ] d) Construction of sheds and wooden structures [ ]

e) Extraction of mineral ores [ ] e) Washing of ores [ ] f) Use of dredger machines [ ]

g) Replacement of topsoil and planting of trees [ ]

6. Which of the activities cause serious threats to the forest reserves?

a) Ground fixing of gold detector machines [ ]b) Digging of tunnels, trenches and pits [ ]

c) Blasting and cutting of rocks [ ] d) Construction of sheds and wooden structures [ ] e) Extraction of mineral ores [ ] e) Washing of ores [ ]

f) Use of dredger machines [ ] g) Replacement of and planting of trees [ ]

7. What effects does the above opening cast mining activities have on the condition of the forest reserves? a) Destruction of trees and vegetative cover [

] b) Removal of topsoil and soil erosion [ ] c) Contamination and drying of water bodies [ ] d) Creation of pits, tunnels and trenches in the Forest reserve [ ]e) Destruction of animals and microorganisms [ ] f) Soil compaction and loss of soil fertility [ ] g) Restoration of vegetative cover [ ]

8. Are you aware that the open cast mining activities mentioned in Q7 have effects on managing the forest reserves in the District? a) Strongly Aware [b) Strongly Unaware [ ] c) Aware [ ] d) Unaware [ ]

9. In what ways does the mining activities affect forest management practices in the District? a) Managing the forest reserves becomes difficult if the area is degraded [ ]

b) It makes working in the forest reserve very difficult since one may unknowingly fell into a pit and die [ ] c) It is difficult to reclaim mined areas since it involves huge sums of money [ ] d) Destruction of trees leads to forest encroachment by chainsaw operators and loss of revenue [ ]

SECTION C: TO ASSESS THE MEASURES PUT IN PLACE BY THE FORESTRY COMMISSION TO CONTROL MINING PRACTICES IN THE FOREST RESERVE

10. Are you aware of the measures put in place by management to control mining activities in the forest reserve? a) Strongly aware [ ] b) Aware [ ] c) Strongly not aware [ ] e) Not aware [ ]

11. Mention some of the measures you know?

a) Patrolling and inspections are carried out in the forest reserve [ ]

b) Occasional arrest of miners in the forest reserve by the regional rapid response team and the Military [ ] c) Sensitization in the forest fringe communities about the effects of mining in the forest reserves [ ]

12. What do you suggest?

a) Patrolling and inspections in the forest reserves must be carried out with military personnel [ ] b) Forest guards must be encouraged to carry out intensive patrols in the forest reserves [ ] c)Building quarters for workers close to the forest reserve[ ] d)Persistent arrest of miners in the forest reserve and prosecuting them in the law court [ ]

e) Forming watch dog committees in the forest fringe communities to protect the forest [f) Recruitment of additional staff to carry out regular monitoring in the forest reserves [ ]

13. Why do you want forest reserves to be protected from mining practices? Please explain your answer?

a) The forest should be protected to enable us continue to enjoy the direct and indirect benefits we get [ ]

b) Forest reserves must be protected for current and future generations [ ]

c) To generate revenue from the forest resources [ ]

d) To prevent loss of biodiversity [ ]

e) To prevent pollution, blockage and drying up of water bodies [ ]

f) To prevent loss of soil and fertility [ ]

THANK YOU FOR YOUR COOPERATION

APPENDIX II

INTERVIEW QUESTIONS FOR FORESTRY COMMISSION

PRESBYTERIAN UNIVERSITY COLLEGE, GHANA

FACULTY OF DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

I am carrying out a study on “threats to forest reserve management from mining practices in Tarkwa forest District of Ghana: I would be grateful if you could kindly provide me with answers to the following questions. The information provided would solely be used for academic purposes and your anonymity is assured. Thank you very much for agreeing to take part.

The main objective of the study is to assess threats to forest reserve management from mining practices in the Tarkwa Forest District.

Specific Objectives

1. To examine the open cast mining activities used in the forest reserves.
2. To assess the effects of open cast mining activities on the condition of the forest reserves.
3. To assess the mitigative measures put in place by the Forestry Commission to control mining practices in the forest reserves.

SECTION A:

For research question 1

To examine the open cast mining activities used in the forest reserve

Please Tick X where applicable

1. Kindly indicate if the following takes place in the forest reserves and when it takes place

Mining Process	Tick X where applicable	Remarks
Search for gold		
Determination of quantity of minerals in an area		
Mining Process/Activity	**Tick X where applicable**	**Remarks**
Exposure of the mineral deposit for extraction		
Extraction of mineral deposit from the earth		
Restoration of land after mineral extraction		
Ground fixing of gold detector machines		
Digging of pits, tunnels and trenches		
Blasting and cutting of stones		

Construction of sheds and wooden structures		
Extraction of ores		
Washing of ores		
Replacement of topsoil and restoration of vegetative cover		

For research question 2

To assess the effects of open cast mining activities on the condition of the forest reserves

2. Which of the open cast mining activities has greater impact on forest destruction?

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3. Mention the effects of the above open cast mining activities on the condition of the affected forest reserves in the Tarkwa forest district

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4. Mention the forest management practices that are going on in the Tarkwa forest district

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5. How are the forest management practises affected by the open cast mining activities?

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For research question 3

To assess the mitigative measures put in place to control mining practices in the forest reserves

6. Tick any measures put in place in the Tarkwa forest district to control mining activities in the forest reserve?

a) Patrolling and inspections in the forest reserve by forest guards and the monitoring team [ ]

b) Occasional arrest of miners in the forest reserve by the regional rapid response team and the Military [ ]

c) Sensitization in the forest fringe communities about the effects of mining in the forest reserves [ ]

7. Are measures put in place helping to control mining activities in the Tarkwa forest district?a) Strongly agree [ ] b) Agree [ ] c) Strongly disagree [ ] d) Disagree [ ]

8. What measures do you suggest can effectively help to control the mining practices in the Tarkwa District?

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9. Why do you want the forest reserves to be protected from mining practices?

a) If the forest is not protected it will lose it value [ ]

b) To enable the forest to be sustainably managed for current and future generations [ ]

c) To continue to enjoy the direct and indirect benefits from the forest reserve []

d) To prevent contamination, blockage and drying of water bodies [ ]

e) To prevent loss of biodiversity [ ]

f) To prevent soil loss and soil erosion [ ]

g) Soil compaction and loss of fertility [ ]

THANK YOU FOR YOUR COOPERATION